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1920

CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, Minister; - - CHARLES CAMSELL, Deputy Minister

MINES BRANCH
JOHN McLEISH, Director

SUMMARY REPORT

OF INVESTIGATIONS MADE BY THE

MINES BRANCH

DURING

THE CALENDAR YEAR ENDING DECEMBER 31

1920

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ERRATA

Page 41—For line 11, substitute: "per cent (or 41 per cent from the raw peat), and a percentage increase in calorific"

Page 43—Between lines 28 and 29 of text insert: "Dowling's split volatile ratio is 'Fixed carbon + ½ volatile matter' divided by"

Page 43—Line 8 from bottom, *read* those, *not* "them."

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DEPARTMENT OF MINES

CANADA

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SUMMARY REPORT OF MINES BRANCH INVESTIGATIONS: 1920

METALLIFEROUS MINES DIVISION

I

THE DEVELOPMENT OF CHEMICAL AND METALLURGICAL INDUSTRIES IN CANADA

Alfred W. G. Wilson

Chief of Division

A comprehensive report on the development of the Chemical and Metallurgical Industries in Canada has been in course of preparation during the last four years. This work has entailed investigation and inquiry in all branches of industry where metallurgical or chemical products or processes are employed. The work was undertaken as a contribution towards the foundation of new industries in this country; to assist in the development of our natural resources; and to show where these resources might be further utilized to advantage. This report, which is now nearing completion, is to be regarded only as preliminary to similar and more comprehensive reports. It presents a generalized view of the present status of the chemical and metallurgical industries in Canada. The subject under review is too broad and too comprehensive to be adequately covered in a single report, or by a single individual.

The most important economic problem before the people of Canada to-day is the expansion of industry, not alone to meet local needs, but also to furnish surplus manufactures to be exchanged for commodities required by us, but not produced in this country. The four primary or fundamental industries of Canada are agriculture, mining, forestry, and fisheries; all other industries are based upon these, both as sources of raw materials and for the maintenance of the industrial workers. Agriculture provides occupation for a very large part of our population, and the annual value of its products exceeds that of any other group. It is erroneous to assume that these facts alone constitute agriculture as the basic industry of this country. To do so is to ignore the meaning of the term basic. Very little investigation and thought are necessary to demonstrate that minerals and mineral products are the basis of all the fundamental industries. The progressive development of civilization since the dawn of recorded history has been marked by the invention and development of processes or methods of utilizing mineral products for industrial or other purposes. Plant growth even under natural conditions can take place only where plant food is available, and certain mineral products form essential plant foods. Agriculture and forestry under the most primitive conditions are dependent upon plant growth, and are thus dependent also upon the presence of suitable mineral products as sources of food. The most advanced agricultural practice of to-day is dependent for its success not only upon an adequate supply of plant foods derived from mineral products by chemical processes, applied artificially or under natural conditions, but also upon implements suitable for intensive cultivation and economical operation, which are fashioned largely from mineral products.

Minerals and mineral products are essential to the production of all other commodities. The winning of minerals—that they may be utilized in the industries—is, therefore the basis of all industry, and this fact alone constitutes mining as the basic one of the four fundamental groups.

While, however, mining is the basic industry of this country, it is the second in importance of the fundamental industries. Its products are essential to progress in all other industries, and when not produced at home, must be imported, often at considerable expense. Ten years ago, according to data obtained from the last census records, 34·4 per cent of our workers were engaged in agriculture, 18 per cent in manufacturing of various kinds, and only 2·3 per cent in and about mines. It is probable that the next census (1921) may show a considerable increase in the percentage of workers engaged in manufacturing, and in mining, and a decreased percentage occupied in agricultural pursuits. A study of the per capita values of the returns credited to the workers in various industries shows that the workers in the mining industry produce, on an average, annually, larger values as the result of their labours than do the average workers in any other large group. A very large proportion of our foreign purchases are fabricated mineral products. Expansion of other industries than mining will naturally lead to increased importations of necessary products not available at home. Owing to the demands of our own industries, and the requirements of the workers in these industries, and owing to the demands of foreign markets for many fabricated mineral products, it is probable that the mining industry and its related groups of industries offer better opportunities for greater expansion and development than any other group. In these days of economic stress, increased production in essential industries is urgently needed; but it must not be forgotten that markets to absorb this production and purchasing power in these markets are also equally essential.

How far the prosperity of the country is dependent upon the Mineral Industry can be determined only by a broad and close economic study of the intimate interlocking relationships which exist between all industries. The dependence of this country upon mining as one of the principal sources of national prosperity is well illustrated by a study of railway statistics. In the year ending June 30, 1916, 34·52 per cent of the total freight loaded upon railway cars in Canada was classed as "Products of the Mine." In the same year the "Products of Agriculture" supplied 24·72 per cent; Forests, 15·10 per cent; and Animals, 3·56 per cent. Manufactures contributed 15·30 per cent, of which 7·18 per cent were primary manufactured products derived from minerals, and 8·20 per cent were partly, at least, of other origin. This last item, however, includes machinery and other materials containing metals and chemicals prepared from minerals. Making allowances for the freight tonnage delivered to Canadian railroads by the United States roads in 1916, 22·6 per cent of the total freight loaded on cars in Canada was the product of Canadian mines, with which may be included 5·2 per cent of primary manufactured products derived from ores and minerals. If the total freights of Canadian origin only are considered, these amounts become 29·7 per cent and 6·9 per cent respectively. Summarizing these data, it may be stated that 36·6 per cent of the freight of Canadian origin loaded on Canadian railway cars, in Canada, was supplied by the mining industry. These figures do not include the inward bound supplies required by the mining industry and its workers. No information is available with respect to this item, but it is probable that if this were included, it would be found that nearly half the freight loaded on cars in Canada is due to the existence of the mining industry. In the United States the mining industry supplies about sixty per cent of the total freight carried on United States railways. Coal and iron ores are the principal mine products contributing to this total.

While about one-third the freight loaded on cars in Canada is directly or indirectly produced by the mining industry, only about 1 per cent of the total population, or, at most, 2·5 per cent of that portion of the population engaged in gainful occupations, is required in the whole Canadian mining industry. It is believed that this proportion has increased slightly during the last ten years.

As previously mentioned, mineral products and commodities made from minerals are essential to all other lines of industry. Where these are not produced, it is neces-

sary to obtain them outside the country, by barter and exchange. The total value of the imports of minerals and manufactures of mine products was $324,263,177 in 1919 and $356,990,627 in 1918.[1] These statistical data do not include many chemical products made from minerals, or products made from other materials by processes requiring the use of minerals. Were these items included, the total importations of this class of commodities would be found to be about $450,000,000 per annum. In 1919, we imported iron and steel products to the value of $181,332,310 in addition to $4,706,440 worth of iron ores. In the same year our coal and coke importations were $63,566,539, and petroleum and petroleum products cost $29,451,974, a total of $279,047,263 for these three items alone. In 1917, these three items totalled $292,213,006, and in 1918, $295,402,436. These valuations represent, approximately, the purchasing cost, exclusive of exchange, of materials of the classes here under discussion that are required by Canadians, and by Canadian industries, over and above the materials now supplied to these industries and to our people, from domestic production. The total value of our imports in 1918 was $963,510,679, and in 1919 was $919,705,802. It is, therefore, apparent that nearly one-half of our annual imports are the products of the mineral industry and of industries closely related thereto, particularly the metallurgical and chemical industries.

Canada is known to be rich in mineral resources, and these resources are by no means fully utilized. Many of the products imported are fabricated by the use of minerals known to occur in Canada. It, therefore, becomes desirable to ascertain underlying causes which result in these large importations of minerals and other products related to them, since it would be of national advantage if our own resources were further utilized in satisfying our own needs, whenever this is at all commercially practicable. The utilization of our own resources for this purpose alone would mean either the expansion of existing industries or the development of new ones.

The successful development of a new industry depends upon the co-operative operation of at least eight different factors, not including the personal factor of organization ability which must be supplied or otherwise procured by those initiating a new enterprise. These eight factors are: (1) supplies of suitable raw materials; (2) capital; (3) industrial research, or a knowledge of the results of research; (4) technical operating skill; (5) labour; (6) salesmanship; (7) transportation facilities; and (8) markets. Each new development will have to be considered by itself, and also in its possible relations to existing developments of like character. The initial steps in the development of a new industry involve a study of the present situation in respect to the supply of raw materials, markets available, transportation facilities, and existing industries of like character. This report has been prepared to facilitate inquiries of this kind.

The report upon the Development of the Metallurgical and Chemical Industries in Canada presents a general summary of the Canadian situation in this field. This review was first planned early in 1916, but special war work prevented the initiation of the principal field investigations until 1917. Since then, almost all the information contained in this report, and much that has been omitted, has been available to those entitled to it; but it did not appear desirable to publish any results of the inquiry, in report form, until after the close of the war. Pressure of other duties and the preparation of certain special reports have delayed the completion of this report until the present time.

The investigations upon which the report is based were primarily undertaken to supply information for war purposes. It was also realized that when peace came it would be very desirable to have accurate information available with respect to the present development of the metallurgical and chemical arts in Canada. The initiation of new lines of endeavour, and the expansion of the old, would necessarily depend upon a knowledge of what had been already accomplished.

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[1] Statistical data compiled by the Division of Mineral Resources and Statistics from returns prepared by the Department of Customs.

The mineral industry is our most important economic industry, in that it supplies raw materials not alone to the two allied industries under discussion, but also to all other industries. Metallurgical industries are based upon the mineral industry, and those manufacturing industries which fabricate metallic products, are, therefore, all dependent upon mineral products. Chemical industries also draw at least seventy-five per cent of their raw materials from the mineral industry. Probably less than one-fourth of our chemical manufacturing industries draw their principal raw materials from the other basic sources of supply. Even in these cases it will be found that certain materials, required in minor quantities, but none the less essential, are either minerals or chemical products derived from minerals. Because of this very intimate dependence of practically all chemical industry upon the mineral industry it has been considered desirable to include in this report references to a number of chemical industries whose principal raw materials are derived from other basic sources.

The more important subjects presented in this report are:—

1. Metallurgical and chemical industries now established in Canada.
2. Metallurgical and chemical products now being produced in Canada.
3. Mineral products, including chemicals, used in industry.
4. Home markets, and the export trade.
5. Sources of raw materials, domestic and foreign.

II

INVESTIGATION OF TITANIFEROUS ORE DEPOSITS

A. H. A. Robinson

During 1920, part of the months of March and April, all of July, August, September, and part of October, were devoted to field work; the remaining portion of the year was spent in the office in working up data collected in the field; in the preparation of reports and maps; abstracting and filing information of interest in connexion with the Canadian iron industry; and supplying, in answer to inquiries, such information as is available regarding Canadian iron ore deposits.

The field work in March and April was undertaken for the Ontario Department of Mines, as a consequence of certain reports on the results of field observations made by officials of that Department, during the summer of 1919, at Kashaweogama lake; a long, narrow body of water situated about twelve miles north of Bucke station, on the Canadian National Railway, near the western extremity of what is known as the Lake Savant iron range, Thunder Bay District, Ontario. In view of the nature of these reports, the Deputy Minister of Mines for Ontario, Mr. Thos. W. Gibson, deemed it advisable to have the more or less casual observations on which they were based supplemented by an accurate magnetometric survey of the lake, and applied to the Mines Branch for the skilled assistance necessary to put such a proposal into effect. In response to this request, the services of the writer were placed at Mr. Gibson's disposal, and, it being necessary to carry out the work on the ice before the spring break-up, a start was made for the field in the early part of March; Kashaweogama was reached about the nineteenth of the same month, and work commenced.

Concurrently with the magnetometric survey, a traverse of the lake was made, also for the Ontario Department of Mines, by Mr. J. S. Dobie, O.L.S., of Thessalon, Ont., to whose capable and experienced hands was entrusted the provision of transportation from the railway to Kashaweogama and return, camp accommodation in the field, and the help necessary to carry out the magnetometric survey as well as

his own work. Grateful acknowledgment is due to Mr. Dobie, whose able management and hearty co-operation did much to facilitate the magnetic work. A chart showing the results, together with a report on the magnetometric observations made at Kashaweogama lake, were forwarded in due course to the Ontario Bureau of Mines.

The investigation of our titaniferous iron resources, which was begun in 1919, was continued during the months of July, August, September, and the first half of October, 1920; also, many non-titaniferous iron ore occurrences, not previously reported on by Mines Branch officers, were visited and examined, to make more complete the data for a revised edition of "Iron Ore Occurrences in Canada".

Leaving out of consideration titaniferous iron sands, Canadian deposits of titaniferous iron, if we include in this category only those containing a noteworthy quantity—say 2 per cent and upward—of titanium, show the general characteristics of titaniferous iron deposits the world over; that is to say, they occur as magmatic segregations in the interior portions of basic igneous rocks of the gabbro family, either as sharply-outlined, irregular, often dike-like bodies, or as irregular masses that pass gradually on all sides of their central core to normal rock. The sharply-outlined type is characteristic of the non-magnetic, high-titanium ilmenites, found in anorthosite at St. Urbain and Ivry, and of some of the deposits that occur in parts of the great anorthosite mass that lies along the north shore of the lower St. Lawrence, in Quebec. They probably owe their form to segregation having taken place at depth, and the resulting titaniferous iron subsequently intruded into the already partly solidified anorthosite. The gradational type of deposit includes many occurrences in Quebec and all those in Ontario; all consisting of titaniferous magnetite (titanomagnetite), as contrasted with non-magnetic ilmenite, and characteristically associated with gabbro rich in ferromagnesian minerals. These show every evidence of segregation *in situ*.

Restricting, as before, the term to those containing two per cent or more titanium, the known titaniferous iron deposits in Canada of any considerable size are, with one exception, confined to the provinces of Ontario and Quebec; and close examination of these deposits leads to the conclusion that a not uncommon belief in great tonnage reserves contained in them is not entirely warranted by facts. Titaniferous iron deposits originating by magmatic segregation occasionally attain considerable dimensions, such as those at Routivare and Taberg in Sweden; and at Sanford Hill, N.Y., and Iron Mountain, Wyo., in the United States. The greater number, however, are substantially smaller. Many are quite small, but may occur as numerous aggregates collected near one another that give rise on a mere cursory inspection to false ideas of their size and continuity; neighbouring outcrops are assumed to represent a single partly hidden ore-body, whereas they actually represent numerous but small, separate ore-bodies scattered through a matrix of lean or barren rock. It may also be pointed out that even when the total amount of material contained in a number of such small neighbouring bodies is large, when scattered about in this way it presents difficulties in prospecting, mining, and handling that may materially affect, economically, its availability. In the case of the titano-magnetites, the magnetometer often affords a cheap and fairly rapid means of determining the continuity or otherwise of deposits of this kind; the non-magnetic ilmenites, however, do not lend themselves to magnetometric methods of investigation.

Some of the ilmenite deposits at St. Urbain and at Ivry, in Quebec, show promise of considerable size for deposits of their class, and they are known to be surrounded by large areas of possibly ore-bearing rock; but exploration has not been extensive enough to make possible any numerical estimate of the amount of material contained in them, either individually or in the aggregate.

Some large bodies of titanomagnetite, together with more numerous small ones, occur north of Seine bay and Bad Vermilion lake in the Rainy River district of Ontario, and in Bourget township in the Lake St. John district of Quebec. The

size and extent of the Rainy River district deposits have been investigated to some degree by magnetic surveys and diamond drilling; knowledge of the Bourget township deposits is confined to the evidence afforded by natural outcrops and some dip-needle readings. Less important occurrences of titanomagnetite are those found at Bay of Seven Islands on the north shore of the lower St. Lawrence, and in the townships of Lake and Tudor in central Ontario. These latter consist of numerous small bodies of titaniferous magnetite lying in such close proximity to each other and surrounded by rock so closely resembling magnetite on casual inspection as to simulate, at first glance, large continuous ore-bodies. Oft-mentioned deposits near Gooderham, Ontario, are of the same nature, but apparently contain fewer concentrations of ore.

In addition to the deposits in Ontario and Quebec, the only other deposit of titaniferous iron of notable size so far reported to occur in Canada is one near Burmis in Alberta—differing both in origin and mode of occurrence from any of those previously mentioned in that it consists of indurated beds of titaniferous magnetite sands intercalated in a series of sandstone beds. At least three different beds of the magnetic black sand have been recognized, and the deposit has been traced in prospect workings for a distance of eight miles in the vicinity of Burmis; similar beds of titaniferous black sands, at the same geological horizon, are reported by the United States Geological Survey to occur to the southeast, in the state of Montana. The titanium content of the beds, though above the maximum usually allowed in iron blast-furnace practice, is small; and the deposit, owing to its probable great extent and proximity to the coal fields, may, in the absence of more suitable material, have a possible future importance as the basis of a local iron industry.

NON-METALLIFEROUS MINES DIVISION

I

MINERAL PIGMENTS IN EASTERN CANADA

Howells Fréchette
Chief of Division

The investigation of the resources of iron oxide pigments was commenced in 1919, in which year the majority of known deposits in the province of Quebec were visited. During the summer field season of 1920, the investigation was continued in the eastern part of Quebec, in New Brunswick, and in Nova Scotia.

Quebec

The only deposits of importance seen in that part of the province of Quebec visited in 1920, are situated on the property comprising lot 18, range I, and lots 19, 20, 21, and 22, range II, Iberville township, Saguenay county, near the mouth of Petite Romaine river, which flows into the St. Lawrence river at a point about 130 miles below Quebec. Iron oxide has been deposited in a more or less crescent-shaped deposit, or series of deposits, about three-fourths of a mile in length, along the southern margin of a very large bog. The ochre varies considerably in depth. In places, on the flat, it approximates to four or five feet in depth; while in some gullies the depth is greater. Twelve feet of ochre was observed in one place; and it is said that in another, drilling revealed over eighteen feet of the mineral. Several shades of ochre were seen, and duly sampled for testing.

These deposits were first worked as a source of pigment, in 1883, but were later abandoned. In 1916, work was again started, and a small quantity of crude ochre was produced for use as a pigment in paper making. Since then, several small shipments have been made. At the time of my visit, a company—under the management of Mr. P. L. Jobidon—had begun the installation of a plant for calcining and grinding the ochre for paint. There is no railroad in the district, shipment being made by small schooners, which are loaded at low tide.

Deposits, which are said to be of considerable size, are known to occur in the township of Manicouagan on the north shore of the St. Lawrence. Owing to their remoteness from markets, and the difficulty of reaching them, they were not visited.

To the south of the St. Lawrence, ochre was observed in a number of places, but nowhere were any deposits seen that could be classed as of commercial interest.

New Brunswick

A number of localities were visited in New Brunswick, for the purpose of examining reported occurrences of iron and manganese pigments. The more important of these are mentioned below.

Near Dawson Settlement, Albert county, there is a deposit, or rather a group of deposits, of bog manganese. These are low spreading mounds, built up by deposition from several springs; and consist of loose, earthy hydrated oxides of manganese and iron, mixed throughout with much peaty matter. At one time this material was used for the production of ferro manganese, but none has been excavated since 1900. In connexion with an investigation of the manganese resources of Canada, Mr. W. L. Uglow made a thorough examination of the two main deposits for the Munition Resources Commission.[1] In his report, he estimates an equivalent of 13,486 tons of

[1] Final Report Munition Resources Commission of Canada, 1920, page 79.

dry ore in the deposits and in the stock sheds; and gives as an averaged analysis, based on dry ore: manganese 22·79 per cent, and iron 15·89 per cent.

The writer visited these deposits for the purpose of determining whether the material could be used for the manufacture of paint. It was found that there is a considerable variation, both of colour and composition, in the different parts of the deposits. The variation of colour, or rather shade, should not render the deposits unworkable for pigment production, but would mean that careful grading would be necessary in the handling of the material.

When washed, dried, and ground in oil, samples produced a warm, dark brown paint, of strong tinting power, similar to raw umber; though of a somewhat redder tone.

When calcined, and ground in oil, some of these samples produced a true burnt umber; while others developed a much redder brown. In all cases, a paint of good body and tinting power was produced.

In Westmoreland county, about twenty miles to the northwest of Dawson Settlement, similar beds of bog manganese occur along the main Canaan river and its upper north and middle north branches. A group of these on the west bank of the upper north branch, is estimated by Mr. Uglow[1] to contain about 5,000 tons (dry weight) of ore. According to the report, this material contains a greater percentage of manganese and of organic matter, and a lesser percentage of iron than the material in the Dawson Settlement deposits. Irregularity in composition, and the hard gritty nature of the ore, in places, would indicate that it is much less desirable for pigment purposes than that from Dawson Settlement. In view of the inferior nature of the material of these deposits, as pigment, they were not visited in connexion with the present investigation, but yet are worthy of mention.

About three miles northeast of Canaan station on the Canadian National Railway (Intercolonial), there are deposits of ochre situated within an immense swamp. In places, springs have deposited iron oxide on top of the debris of the swamp. One such deposit, several acres in extent, was examined and sampled. Much of the iron oxide is mixed with a large proportion of peaty matter, though in patches high grade material was obtained. Owing to many logs and roots embedded in the deposit, it was impossible to determine its depth. In some sections, the ochre is found merely as a surface layer, a couple of feet thick; while the greatest depth observed was eight feet thick. Samples tested in the laboratory show that a good paint may be produced by calcining the material. The colour of the raw material, ground in oil, varies from a very dark brown to a medium toned sienna; and when calcined produces a paint of good intensity, somewhat similar to burnt sienna. Owing to the large amount of embedded wood, and the difficulty of draining such a large swamp, the exploitation of this deposit would probably be costly.

Nova Scotia

Some twenty reported occurrences of mineral pigments were visited in Nova Scotia. These were of three classes: namely, iron oxides, iron-manganese oxides, and clays. The clays, in all cases, may be dismissed from consideration as raw material for colour making, on account of their lack of brilliancy and low staining power.

With few exceptions, the iron oxide deposits are very small, and consequently of no commercial value. Most of these deposits are formed by the precipitation of iron from water oozing out of beds of shale containing pyrite, the weathering of which yields the iron in solution.

Such deposits were observed in Inverness, Antigonish, Pictou, Halifax, Lunenburg, Queens, and Kings counties.

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[1] Final Report Munition Resources Commission, p. 65.

The ore in the iron mines near Londonderry, Colchester county, contains much earthy limonite, which, in some cases, is of very fine texture, and of good sienna colour, and is said to be quite suitable for paint manufacture. These mines have been shut down since 1908; and as none of the workings were accessible, no samples could be obtained for examination. It is doubtful if it would pay to open any of the old workings for the production of pigment; but should the mining of iron ore be resumed at any time, a separation of the ochre from the ore might be a profitable enterprise.

On the Southwest Branch Avon river, between Benjamin Mills and Upper Falmouth, Hants county, about seven or eight miles by road from Windsor, there are a series of deposits of manganiferous iron oxides, some of which are of workable size. Several shades of paint of good quality were obtained from samples of the material. Owing to the covering of timber on the deposits and the distance from the railroad, exploitation would probably be costly. It is understood that a license to the property is held by John A. Spencer of Windsor.

In Kings county, about 3½ miles southwest of Kentville, there is a fairly extensive deposit of manganiferous iron oxide on the farm of Chas. W. Ward. According to How,[1] several hundred tons of pigment was taken from this deposit, and marketed in the United States. The samples collected, when ground in oil, yielded paints of good quality. The colours of the paint, made from the uncalcined material, ranged from dark raw sienna to a warm seal brown, while the calcined gave paints ranging from a bright red to very dark brown, similar to burnt umber. The deposit contains, in places, thin beds of nodular wad and bog iron ore. There is little intermixed sand, except in a few isolated patches.

About twenty years ago, umber was shipped from a property at Chester Basin, Lunenburg county. The deposit is situated close to the railroad, on the property of Mrs. Chas. H. Mills. The deposit, which is about four feet thick, is overlain by two or three feet of soil. The old pits have caved in, but one of these was opened up sufficiently to obtain samples. Good grades of paint were obtained by grinding the material, both raw and calcined, in oil. The respective colours were raw and burnt umber, although slightly warmer in tone than the standards.

II

INVESTIGATION OF MISCELLANEOUS NON-METALLIC MINERALS

Hugh S. Spence

BARYTES

During the field season of 1920, an examination was made of several barytes deposits in northern Ontario, in order to complete the data for the writer's report on "Barium and Strontium in Canada" which will shortly go to press. None of the properties visited have attained the producing stage, the majority being situated too far from a railroad to permit of their being worked under present conditions.

A deposit in Lawson township, near Elk Lake, was described in the Summary Report of the Mines Branch, 1919. Analyses since made of the samples of ore taken from this deposit show the barytes to be of exceptionally good grade, running 98 per cent barium sulphate, in addition to being soft and very white. While surface indications do not point to there being a very large body of ore, the deposit should prove of value as soon as rail communication is extended from Elk Lake to Gowganda. At present, the 15-mile road haul to Elk Lake renders development of the property impracticable.

[1] Mineralogy of Nova Scotia by Henry How, 1868, p. 109.

The deposit of the Ontario Barium Company, situated in Yarrow township, about 35 miles northwest of Elk Lake, comprises several important veins, and the property is capable of yielding a large tonnage of barytes. The remoteness of the locality, however, renders exploitation out of the question at the present time. The barytes is of good quality, and two heavy veins have been uncovered, in addition to several smaller leads. Up to the present time only surface work of a prospecting nature has been conducted. The four claims controlled by the company were surveyed for patenting during 1920, and the construction of the projected railroad to the Matachewan area is being awaited before further development is undertaken.

A deposit of barytes also exists in the township of Cairo, Matachewan district, about 12 miles in a direct line northeast of the above noted occurrence in Yarrow township. This deposit, known as the Biederman property, consists of a single vein of fair quality barytes, measuring 16 feet between walls, but containing a considerable amount of included country rock. In addition, sulphides occur in the ore, and a narrow siliceous zone persists to a width of about 30 inches along the hanging contact. In general, the ore may be considered as rather inferior in grade to that of the other deposits examined in northern Ontario. The length of vein exposed is about 85 feet. Lack of transportation hinders any attempt to develop this deposit, upon which only surface work has been done.

A deposit of barytes near Tionaga, 135 miles west of Sudbury, on the Canadian National railway, was stripped and diamond drilled by C. H. Hitchcock and associates, of Sudbury, during 1919-20. The occurrence consists of a single ore body made up in part of anastomosing stringers of good, white barytes. These stringers are associated with a considerable amount of massive quartz, and a proportion of the ore would probably have to be cobbed. The ore body has been stripped for 450 feet, and is exposed on a low knoll; at each end of the outcrop the lead passes under a swamp. Drill holes have been carried to a depth of 150 feet, and the tonnage of barytes available to this depth is estimated by the operators at 50,000 tons. The property is situated within a few hundred feet of the railroad tracks, though below their level, and the construction of a spur of about half a mile will be necessary to enable ore to be dumped directly into cars.

CELESTITE

The celestite deposit in Bagot township, Renfrew county, Ontario, described in Mines Branch Summary Report, 1919, was again visited, late in the season. Considerable mining was done on the deposit during 1920, and a small experimental mill was erected, to grind the material. Some shipments were made to domestic paint firms, and the celestite is reported to have substituted satisfactorily for barytes in paints.

The ore of this deposit is very mixed, consisting of irregular, detached masses of fibrous and rather friable celestite, enclosed in a dolomite matrix. It is probable that this mode of occurrence will alter in depth to a more regular vein formation, as the detached masses of celestite at the surface appear to be portions of a brecciated vein. All of the celestite recovered is secured by hand cobbing, and the actual amount of celestite recoverable by this means from the mixed celestite-dolomite cobbing ore probably does not exceed 30 per cent of the total present. The remaining celestite is present intimately mixed with dolomite, and the mixed rock would require to be concentrated in order to effect a satisfactory recovery. Such mixed rock averages about 50 per cent celestite.

TALC

Examination was also made this season of several talc properties in British Columbia.

A deposit of massive talc, or steatite, that has been known for many years, is situated 3 miles west of Keefers Station on the main line of the Canadian Pacific

railway. No talc has been shipped from this property, but the talc body has been exposed in several openings made for gold. The talc occurs as a band of green, massive steatite, enclosed in slates; the entire series being tilted into a vertical attitude and being much jointed and squeezed. Little of the talc comes out in the form of compact blocks of any size, the material breaking up into irregularly shaped pieces, with slickensided surfaces. As far as could be ascertained from an examination of the tunnel that crosses the talc body, the latter has a width of about 8 feet, and is bordered on both sides by about 25 feet of more or less talcose slate (soapstone). The talc grinds to a soft, grey-white powder, that should prove suitable for the paper, paint, rubber, and roofing trades. The property is well situated for working, lying close to, and higher than, the railroad tracks. The present operators are the B.C. Silica & Talc Company, Rogers Building, Vancouver, who mined only quartz during 1920.

A talc deposit on Wolf Creek, Victoria Mining Division, Vancouver Island, was visited and found to be working on a small scale. The property is situated 33 miles from Victoria, and about three-fourths of a mile from the track of the Canadian National railway. The deposit consists of a narrow band of grey-green talc schist, dipping about 60°. The talc zone is enclosed in slates, and the whole is considerably squeezed and crumpled. A tunnel has been carried 50 feet along the talc body, and is reported to show 18 feet of ore. The operator is W. G. Dickinson, 576 Dallas Road, Victoria, who has taken out about 300 tons of talc. This material was shipped to his grinding mill at Sydney, and ground for roofing purposes. Mr. Dickinson states that the quality of the talc has been favourably reported on by Pacific coast paper mills, and that contracts have been entered into to supply crude talc to American mills in Washington. The talc of this deposit is evidently an altered, coarse-grained schist, and contains an appreciable amount of dolomite; it grinds to a light grey powder. The deposit carries no massive talc, suitable for cutting into slabs.

A small tonnage of talc has been obtained in recent years from deposits at Mile 92, near D'Arcy, on the Pacific Great Eastern railway, Lillooet Mining Division. All of the talc taken out has been utilized for surfacing roofing paper, the principal operator being the Pacific Roofing Company, Granville Island, Vancouver. The talc is grey-green in colour, carries minute specks of disseminated bornite, and grinds to a soft, nearly white powder. It shows evidence of crumpling, and breaks up readily into thin layers.

No work was done during 1920 on the steatite deposit near Vermilion Summit, Windermere Mining Division, but it is understood that the deposit has been found to extend beyond the limits of the original claim.

BENTONITE

Consequent upon enquiries directed to the Department by the Imperial Mineral Resources Bureau, regarding possible sources of bentonite in Canada, the writer was instructed to visit localities in Alberta and British Columbia, from which bentonite had already been recorded; to gather all available data regarding the occurrences; take samples, and to examine, also, any new deposits that might be brought to his attention. In accordance with these instructions, visits were made to three localities along the line of the Canadian National railway, between Edmonton and Calgary, and to one known occurrence in the interior of British Columbia. Samples were taken of the various beds examined, and the material was shipped to the Mines Branch laboratory for investigation as to its chemical and physical properties. Samples were also sent to the Imperial Mineral Resources Bureau, in order that similar work might be carried out upon the material by the Department of Scientific and Industrial Research.

The work being done in the Mines Branch laboratory has not yet reached a stage that will enable definite conclusions to be drawn regarding the suitability of these

Canadian bentonites for industrial purposes. It has been shown, however, that certain of the samples compare very favourably with the Wyoming bentonite that was employed as a standard in the investigation. Unfortunately, the deposits from which this good grade of material was taken, are all very thin, scarcely exceeding 12 inches, and consequently they can in most instances hardly be regarded as of economic importance.

Mr. A. E. Thompson, chemist in charge of the laboratory work being conducted on bentonite, states he has reason to believe that certain samples of what was at first regarded as inferior bentonite, owing to the apparent failure of the material to gelatinize readily on the first addition of water, show indications of improved behaviour on prolonged immersion, with agitation. It is possible, therefore, that certain deposits of workable dimensions, which were at first thought to carry only material of inferior grade, may yet prove to be of economic importance.

III

ALKALI DEPOSITS OF WESTERN CANADA

L. H. Cole

Occurrence.—Natural occurrences of soluble mineral salts are known in the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia, either in the form of bedded deposits, or as brines. Some are of considerable extent, and are probably of sufficient size to warrant commercial development.

The occurrences of these salts may be broadly classed under two types:—

(1) Solid salts and brines in undrained or partially drained basins;
(2) Brines of flowing streams or springs.

Type 1

Those of the first class are very numerous in the Prairie Provinces.

It is probable that the accumulation of salts is due to leaching out of the soluble salts in the prairie soils by surface waters, and their concentration and deposition in the undrained basins which are found in the glacial morainic covering of the western prairies.

These deposits are generally of a similar character, although the percentage of the different salts will vary in different localities. In many cases the name "alkali lake" has been appropriately applied to deposits of this nature, since in the early spring and often into late summer the deposits are covered with water. The water accumulating through the melting snow and rain is often a foot or two in depth, and carries a considerable quantity of the alkali salts in solution. Beneath this water one generally finds a solid bed of crystallized salts. In the late summer, especially when the season is a dry one, these so-called lakes become deposits of snow white alkali, which when seen from a distance resemble snow covered basins.

The deposits will vary in size from a few acres to many acres in extent, and in thickness from a few inches to possibly 15 feet. The salts are generally found interbedded or mixed with mud or peaty material, and in very few instances are the deposits in a pure enough form to be commercially marketable in their raw state. The mud beds also contain numerous crystals of the alkali salts.

Type 2

Brine streams or springs occur in many places, and may carry sufficient salts in solution to warrant their commercial exploitation for medicinal and other pur-

poses. In some of the occurrences of this nature the principal salt present is sodium chloride, the other salts being present only in small quantities. The brine springs of northern Manitoba are good examples of this class of deposit.

Composition.—The composition of the salts occurring in these basins consists chiefly of mixtures of sodium and magnesium sulphates in varying proportions, with, generally, small quantities of sodium chloride and possibly other salts such as sodium carbonate, etc.

Sodium Sulphate

Sodium sulphate in the hydrous form (known as *Mirabilite* or *Glauber's Salt*) has the following composition:—

$$Na_2SO_4 \cdot 10H_2O = \begin{cases} SO_3 & 24{\cdot}8\% \text{ (sulphur trioxide).} \\ Na_2O & 19{\cdot}3\% \text{ (soda).} \\ H_2O & 55{\cdot}9\% \text{ (water).} \end{cases}$$

In its pure state it is white, transparent to opaque; and has a hardness 1·5-2 with a specific gravity 1·48. It is readily soluble in water, and at first is cool to the taste, and afterwards saline and bitter.

Sodium sulphate in the anhydrous form (known as *Thenardite*) has the following composition:—

$$Na_2SO_4 = \begin{cases} SO_3 & 43{\cdot}7\% \text{ (sulphur trioxide).} \\ Na_2O & 56{\cdot}3\% \text{ (soda).} \end{cases}$$

Its colour, when pure, is white, translucent to transparent, and the mineral has a hardness of 2-3, with a specific gravity of 2·68.

Magnesium Sulphate

Hydrous magnesium sulphate (known as *Epsomite* or *Epsom Salts*) has the following composition:—

$$MgSO_4 \cdot 7H_2O = \begin{cases} SO_3 & 32{\cdot}5\% \text{ (sulphur trioxide).} \\ MgO & 16{\cdot}3\% \text{ (magnesia).} \\ H_2O & 51{\cdot}2\% \text{ (water).} \end{cases}$$

This is a soft, white or colorless mineral, readily soluble in water, and with a bitter saline taste. Its hardness is from 2 – 2·5, and a specific gravity, 1·75.

Sodium Chloride

Sodium chloride (known as *Halite* or *Common Salt*) has the following composition:—

$$NaCl = \begin{cases} Na & 60{\cdot}6\% \text{ (sodium).} \\ Cl & 39{\cdot}4\% \text{ (chlorine).} \end{cases}$$

The natural salt is nearly always impure. It has a hardness of 2·5 and a specific gravity of 2·1 – 2·6. It is colourless or white when pure, but often yellowish, or red or purplish, from the presence of metallic oxides or organic matter. It is readily soluble in cold water, and has a saline taste.

With these salts may be associated other soluble salts such as sodium carbonate, and in small quantities, the salts of the calcium, potassium and alum groups.

On account of the nature of the natural alkali deposits and brines of western Canada, it will be necessary in nearly all cases to purify the raw product from such deposits, in order to produce marketable commodities. A pure Glauber's salt can be obtained by evaporating the brines or by dissolving the soluble salts already deposited and separating the sulphate of soda by differential crystallization. To produce salt

cake from the hydrous salt it will be necessary to develop processes for eliminating the water of crystallization. Theoretically, this appears easy, but there are a number of practical difficulties in the way of development which have not yet been overcome.

Uses.—Sodium sulphate in the anhydrous form is more commonly known by its trade name *Salt Cake.* As salt cake, it finds its chief use in the manufacture of sulphate pulp; in metallurgical work in the refining of nickel; in the manufacture of window, plate and bottle glass; and in making water glass. In the hydrous form, it is marketed as Glauber's salts, and as such, is used in dyeing; in tanning; in the textile industry as a mordant; and in medicine.

Magnesium sulphate or Epsom salts is largely used in the cotton trade for warp-sizing; it is also employed for medicinal and agricultural purposes, and in dyeing with aniline colours, since goods thus dyed are found to stand the action of soap better.

Sodium chloride is the ordinary common salt of commerce, and as such, does not need further mention.

Market Situation.—Sodium Sulphate.—So far there has been no steady production of sodium sulphate from the alkali lakes of western Canada. The Salts and Potash Company, Ltd., of Kitchener, Ont., operating Muskiki lake (Tp. 39, R. 16, W. 2nd), Sask., have erected refining plants at their lake and also at Kitchener, Ont., in which they have carried out considerable experimental work and hope shortly to be in a position to place the refined products regularly on the market. The salt cake so far used in the country has been obtained as a by-product from the manufacture of hydrochloric acid. Glauber's salts are made from the anhydrous form by dissolving the salt cake and recrystallizing below 32·4° C.

Salt cake is manufactured in Canada by the following firms:—

Grasselli Chemical Co., Hamilton, Ont.
Nichols Chemical Co., Montreal, Que.
Plants:—Sulphide, Ont.
Capelton, Que.
Victoria Chemical Co., Victoria, B.C.

The Canadian production of salt cake and Glauber's salts as furnished by the Dominion Bureau of Statistics for 1918 and 1919 was as follows:—

	1918		1919	
	Tons	Value	Tons	Value
		$		$
Salt Cake	6,001	133,544	3,197	57,045
Glauber's Salts	2,358	60,281	1,423	45,731

Canadian imports of salt cake and Glauber's salts are as follows:—

Calendar Year	Salt Cake		Glauber's Salts	
	Amount	Value	Amount	Value
	lbs.	$	lbs.	$
1910	17,728,543	95,054	1,080,309	5,217
1911	13,782,241	88,761	1,531,555	7,826
1912	19,243,823	97,768	1,951,619	9,129
1913	25,902,190	133,030	811,053	3,815
1914	38,175,604	170,333	810,062	3,407
1915	30,970,231	147,047	840,994	8,058
1916	42,194,077	178,370	522,703	8,133
1917	71,583,645	560,711	722,913	16,248
1918	68,773,441	676,571	686,712	9,748
1919	47,905,004	343,007	738,423	9,763

Magnesium Sulphate.—During the year ending March 31, 1920, there was imported into Canada $67,074 worth of Epsom salts, and in the same period, 1,523 cwt., valued at $893, was exported. This export was from the natural deposits of Epsom salts in British Columbia.

Market Prices.—The market prices of these commodities are constantly varying. The following figures as reported in the *Oil, Paint and Drug Reporter,* New York, give the New York market prices for the years 1914 to date.

	Aug. 14 1914	Jan. 1 1915	Jan. 1 1917	Jan. 1 1918	* 1919	* 1920
	$	$	$	$	$	$
Salt Cake, ground—bbls. per ton	11·00 to 13·00	11·00 to 13·00	.....	30·00 to 35·00	12·00 to 30·00	17·60 to 60·00
Glauber's Salts, cwt.	0·65 to 0·75	0·60 to 0·75	0·60 to 0·65	0·90 to 1·00	1·00 to 2·25	1·15 to 3·00
Epsom Salt, U.S.P. cwt.	not quoted	prior to 1918		3·62½ to 3·90	2·75 to 3·62½	2·50 to 6·00
Epsom Salt, tech. cwt.	1·00 1·10	1·75 2·00	1·75 1·85	3·37½ 3·50	1·80 3·37½	1·75 3·75

*High and low figures for year.

IV

BITUMINOUS SANDS OF ALBERTA

S. C. Ells

The field work carried on during the season of 1920 may be considered under two headings: (I) Examination of an area reserved for the use of the Parks Branch, Department of the Interior, situated on Horse river, and known as the "Horse River Reserve"; and (II) Provisional classification of outcrops of bituminous sand in the McMurray District, with regard to their probable economic importance.

(I)

Horse River Reserve.—An examination of the Horse River reserve was undertaken in order to determine the tonnage of bituminous sand commercially available; the quantities of overburden that the mining of such a tonnage would involve; and general conditions affecting development on a commercial scale. Twenty-one test pits were sunk in order to determine the thickness and character of the overburden, and the extent of the area underlaid by commercially available bituminous sands. Subsequently, bore holes were sunk from the bottom of the test pits, and representative samples of the bituminous sand secured. A report dealing with the results of the above work was forwarded to the Department of the Interior in December, 1920.

The following comment on methods applicable to the examination of bituminous sand areas is based on the results of the work on Horse river.

The method adopted in prospecting any bituminous sand area will depend on the thickness and character of material overlying bituminous sand of commercial grade; on the accessibility of the deposits, and the facilities for transportation by water or pack trail.

(a) *Where overburden is light.*—Residual river bottom areas usually have a relatively light overburden of clay, sand, and gravel. Where the thickness of overburden does not exceed 40 feet, exploration by means of test pits will usually be found satisfactory. In only three of the twenty-one test pits sunk during the past summer was cribbing necessary. In these three instances, caving was checked by using light poles and backfilling with brush. When the test pits have reached the bituminous sand, accurate core samples may then be secured by the use of standard asphalt hand augers. In sinking test pits, light pole derricks, rigged with double blocks, winding drum, and self dumping bucket, were used.

This equipment could be erected in from one to two hours. The weight of the heaviest single part did not exceed 75 pounds. A double action hand-pump, equipped with 10 feet of suction and 40 feet of discharge hose, was also used in order to keep down the very considerable volume of seepage water. Men worked in parties of three; but by using an efficient type of windlass, parties of two would have been adequate. The average rate of sinking, up to 25 feet, was approximately 3½ feet per day of 9 hours.

(b) *Where overburden is heavy.*—At points where a stream impinges against the side of a valley, exposures exhibit a thicker section of bituminous sand and also a much heavier overburden. Consequently, in determining the importance of areas represented by such outcrops, prospecting by means of test pits is not practicable. Usually, measurements, and boring by hand augers, along adjacent outcrops, will determine with sufficient accuracy the quality and quantity of the bituminous sand itself. It is more difficult, however, to determine definitely the thickness of the various strata of which the overburden consists. Under such conditions, two methods are possible:—

(i) A trench may be excavated above the outcropping bituminous sand, in order to expose a complete section of the overburden. The use of such a method is, however, rarely satisfactory. Slips in the unstable overburden along the precipitous slopes are frequent; and, apart from the large amount of excavation that trenching will ultimately involve, the final results are rarely reliable.

(ii) A bore may be sunk at some centrally located point within the area under consideration; and although such work involves the use of more elaborate equipment, the information secured is dependable. Light gasoline driven drills,[1] suitable for such work can be secured, of which the weight of the heaviest part does not exceed a few hundred pounds.

In preparing final estimates of quantities of overburden and of bituminous sand, accurate, detailed mapping is obviously essential. In the type of country under consideration the writer has found that maps, showing contours drawn at intervals of five feet, and plotted to a scale of one inch equal to 200 feet, are satisfactory.

Conditions met with in the Horse River reserve may be considered characteristic of a large area lying south of township 93. As an indication of the importance that will attach to the removal and disposal of overburden, it may be stated that on the Horse River reserve, the estimated overburden amounted to approximately 3,180,000 cubic yards. The removal of this overburden would render available, approximately 3,360,000 tons of bituminous sand.

(II)

Classification of outcrops of bituminous sand with regard to their present possible economic importance.

Following the completion of the examination of the Horse River reserve, a short period was spent in visiting various outcrops of bituminous sand along the Athabaska and tributary schemes, within the McMurray district. Conclusions arrived at as a result of the work on Horse river were of value in making a provisional classification of the various sub-areas represented by these outcrops.

[1] Manufactured by the Longyear Co., Minneapolis, U.S.A.

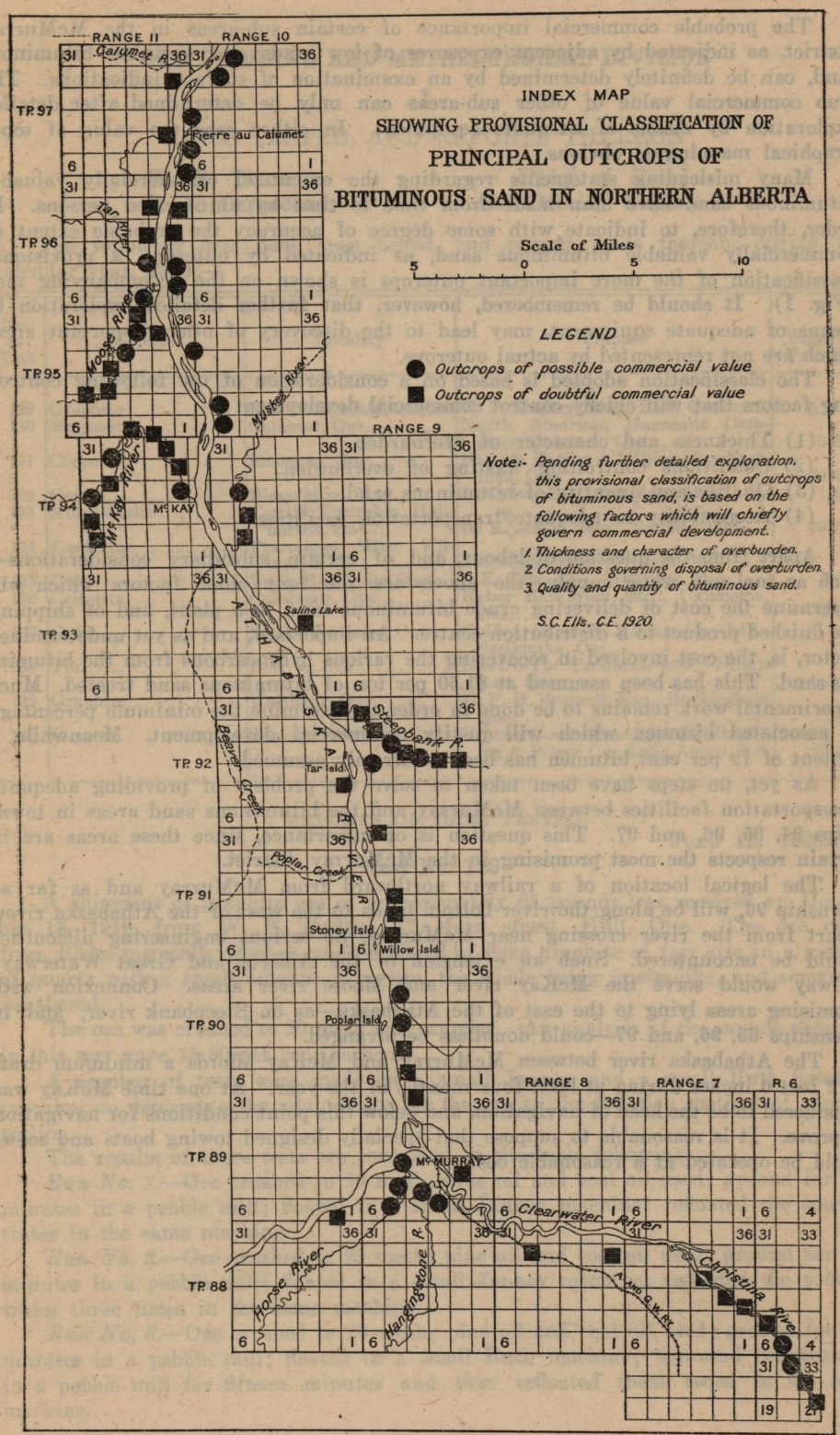
INDEX MAP
SHOWING PROVISIONAL CLASSIFICATION OF
PRINCIPAL OUTCROPS OF
BITUMINOUS SAND IN NORTHERN ALBERTA
Scale of Miles
5 0 5 10
LEGEND
Outcrops of possible commercial value
Outcrops of doubtful commercial value
Note:- Pending further detailed exploration, this provisional classification of outcrops of bituminous sand, is based on the following factors which will chiefly govern commercial development.
1. Thickness and character of overburden.
2. Conditions governing disposal of overburden.
3. Quality and quantity of bituminous sand.
S.C. Ells, C.E. 1920.
RANGE 11
RANGE 10
RANGE 9
RANGE 8
RANGE 7
R. 6
TP. 97
TP. 96
TP. 95
TP. 94
TP. 93
TP. 92
TP. 91
TP. 90
TP. 89
TP. 88
Calumet R.
Pierre au Calumet
Tar River
Moose River
Muskeg River
McKay River
McKAY
Saline Lake
ATHABASKA RIVER
Steepbank R.
Tar Isld.
Beaver Creek
Poplar Creek
Stoney Isld.
Willow Isld.
Poplar Isld.
McMURRAY
Clearwater River
Horse River
Hangingstone R.
Athabasca Trail
Christina River

Fig. 1.

The probable commercial importance of certain sub-areas in the McMurray district, as indicated by adjacent exposures of low grade and worthless bituminous sand, can be definitely determined by an examination of surface indications. The true commercial value of other sub-areas can only be determined after detailed exploration by means of adequate equipment. In either case the value of topographical mapping is obvious.

Many misleading statements regarding the extent of commercially valuable bituminous sand have been made from time to time by uninformed persons. In order, therefore, to indicate with some degree of accuracy the probable extent of commercially valuable bituminous sand, as indicated by outcrops, a provisional classification of the more important outcrops is shown on the accompanying map (Fig. 1). It should be remembered, however, that further detailed exploration by means of adequate equipment, may lead to the discovery of other important areas which are not represented by actual outcrops.

The classification adopted is based on a consideration of the following controlling factors that will chiefly control commercial development:—

(1) Thickness and character of overburden.
(2) Conditions controlling wasting of overburden.
(3) Quality and quantity of bituminous sand.
(4) Accessibility to adequate transportation facilities.

Apart from the question of labour, and of certain subsidiary considerations—such as fuel and water supply—the above are the four chief factors which will determine the cost of delivering crude bituminous sand to a plant, and of shipping the finished product to a distribution centre. An important, and as yet undetermined factor, is, the cost involved in recovering the various hydrocarbons from the bituminous sand. This has been assumed at $1.50 per ton of bituminous sand treated. Much experimental work remains to be done in order to determine the minimum percentage of associated bitumen which will justify commercial development. Meanwhile, a content of 12 per cent bitumen has been arbitrarily assumed.

As yet, no steps have been taken to solve the problem of providing adequate transportation facilities between McMurray and the bituminous sand areas in townships 94, 95, 96, and 97. This question is of importance, since these areas are in certain respects the most promising in the McMurray district.

The logical location of a railway northward from McMurray and as far as township 96, will be along the river bottom lands to the west of the Athabaska river. Apart from the river crossing near McMurray, no serious engineering difficulties would be encountered. Such an extension of the Alberta and Great Waterways railway would serve the McKay river and Moose river areas. Connexion with promising areas lying to the east of the Athabaska—as on Steepbank river, and in townships 95, 96, and 97—could doubtless be arranged.

The Athabaska river between McMurray and McKay affords a minimum draft of 2 feet 6 inches during at least four months of the year. At one time McKay was considered to be the head of navigation, and below this point conditions for navigation improve. It is reasonable to suppose that specially designed towing boats and scows could be operated at a reasonable cost.

ORE DRESSING AND METALLURGICAL DIVISION

I

ORES TESTED, AND REPORTS THEREON

W. B. Timm - - - - - - - - *Chief of Division*
R. K. Carnochan - - - - *Asst. Mining Engineer*

The following ores have been tested, and reports made thereon, during the calendar year, 1920:—

No. of Test	Material	Locality	Shipper	Weight Pounds
129	Graphite	Blake Township, Quebec	W. F. Hadley, Esq., Hull, Quebec	65
130	Magnesite	Calumet, Que.	North American Magnesite Company, Calumet, Que.	5,849
131	Copper	Eastman, Que.	Eastern Mining & Milling Co., Eastman, Que.	50,000
132	Gold	Bingo Mine, Man.	J. Myers, Esq., Winnipeg, Man.	1,000
133	Molybdenite	Cardiff Township, Haliburton, Ont.	W. E. Joiner, Esq., Toronto, Ont.	59,026
134	Lead-zinc	Ptarmigan Mine, Wilmer, B.C.	Ptarmigan Mines, Wilmer, B.C.	6
135	Gold	Little Rice Lake, Man.	J. E. Cole, Esq., Winnipeg, Man.	2,572
136	Celestite	Calabogie, Ont.	Heber Bambrick, Esq., Calabogie, Ont.	2,000
137	Gold	Sesikinika Lake, Ont.	Golden Summit Mining Co. Ltd., Sesikinika, Ont.	100
138	Tin	Bolivia, S.A.	Electro-Tin Products, Ltd., Brantford, Ont.	30
139	Graphite	Waltham, Que.	H. P. H. Brumell, Esq., Buckingham Que.	32
140	Copper	Anyox, B.C.	Granby Consolidated Mining, Smelting & Power Co., Ltd., Anyox, B.C	50,560

REPORTS ON ORES TESTED

June 15, 1920.

Test No. 129

A shipment of graphite ore of approximately 65 pounds was received on December 13, 1919, from W. F. Hadley, 17 Main street, Hull, Que. The ore came from Blake township, Quebec, and consisted of flake graphite of fair size in a gangue of quartz with a small amount of pyrite, the whole being gneiss-like, and somewhat weathered.

The ore was crushed to 20 mesh and sampled. An analysis of the sample obtained in this way gave 15·80 per cent carbon.

A number of tests were made on a small Janney and a small Ruth flotation machine, to determine the adaptability of the ore to the flotation method of concentration.

The results of these tests are contained in the table following.

Run No. 1.—Ore crushed to 20 mesh; pine oil and coal oil used; ground for five minutes in a pebble mill; floated in a small Janney machine; refloated the concentrates in the same machine.

Run No. 2.—Ore crushed to 20 mesh; pine oil and coal oil used; ground for five minutes in a pebble mill; floated in a small Janney machine; refloated the concentrates three times in the same machine.

Run No. 3.—Ore crushed to 20 mesh; pine oil and coal oil used; ground for five minutes in a pebble mill; floated in a small Ruth machine; reground concentrates in a pebble mill for fifteen minutes and then refloated them twice in the same machine.

Test No. 129

CONCENTRATES

Run No.	Wt. of ore taken, grms.	Analysis % C.	Content grams C.	+35 mesh				−35+65				−65 +150				−150			
				Wt. grams	Analysis % C.	Content grams C.	% of C. values	Wt. grams	Analysis % C.	Content grams C.	% of C. values	Wt. grams	Analysis % C.	Content grams C.	% of C. values	Wt. grams	Analysis % C.	Content grams C.	% of C. values
1	1000	15·80	158·0	43·9	76·00	33·4	22·7	89·8	51·05	45·8	31·1	64·2	51·25	32·9	22·4	47·1	59·90	28·2	19·2
2	600	15·80	94·8	21·2	92·45	19·6	21·4	41·2	73·90	30·4	33·2	30·0	64·35	19·3	21·1	15·6	75·80	11·8	12·9
3	1200	15·80	189·6	63·6	87·50	55·6	28·8	106	57·70	61·2	31·7	107·8	34·80	37·5	19·5	63·6	51·55	32·8	17·0

Middlings

No. 1				No. 2				No. 3			
Wt. grams	Analysis % C.	Content grams C.	% of C. values	Wt. grams	Analysis % C.	Content grams C.	of C % values.	Wt. grams	Analysis % C.	Content grams C.	% of C. values
111	2·35	2·6	1·8	.....	.....	.....	.....	.....	.....	.....	.....
20	26·50	5·3	5·8	20	13·80	2·8	3·0	46	2·80	1·3	1·4
44	3·65	1·6	·8	166	·80	1·3	·7	.....	.....	.....	.....

Tailings

Wt. grams	Analysis % C.	Content grams C.	% of C. values
580	·70	4·1	2·8
378	·30	1·1	1·2
631	·45	2·8	1·5

SUMMARY AND CONCLUSIONS

From the results of the test work conducted, the following conclusions can be deduced:—

First.—The ore is adaptable to concentration by flotation of the graphite from its gangue.

Second.—A high-grade flake can be made, as Run No. 2 shows that the +35 concentrates gave an assay of 92·45 per cent carbon. Flotation may have to be assisted by table concentration and by finishing machines, to obtain marketable products. This would require further test work on a larger scale.

Third.—A high recovery is obtainable. The laboratory tests show recoveries of the carbon content of about 95 per cent.

December 31, 1920.

Test No. 130

Ten barrels of crude magnesite, net weight 5,849 pounds, were received March 26, 1920, at the Ore Dressing and Metallurgical Laboratories, from the North American Magnesite Company, Calumet, Quebec.

The magnesite is a mixture of magnesite and dolomite, the magnesite predominating; the dolomite being present in sufficient quantity that the lime content of the crude makes it compare unfavourably with the Austrian and Grecian magnesites, or with that from the States of Washington and California.

The shipment received showed the following analysis:—

CaO	12·85%
MgO	34·94%

Investigation is being carried on to obtain a separation of the lime from the magnesia and to obtain a product that will compare favourably with the foreign material.

A number of tests have been conducted by calcining the crude in a stack furnace at a temperature of from 950° C. to 1100° C., slacking the calcines with a moderate amount of water, and then classifying and washing the lime from the calcined magnesite.

The crude magnesite containing 13 per cent CaO on being calcined gave 25 per cent CaO in the calcines. The test work so far conducted shows that this can be reduced to 9 per cent CaO in the magnesite product by classification and washing. These results, however, are much higher than desired, and further work is being carried on to improve the methods of calcining, as it is in this part of the operations upon which the success of the process will depend.

December 31, 1920.

Test No. 131

A carload of copper ore was received from F. G. Connell, Esq., of the Eastern Mining and Milling Co., Eastman, Quebec, February 8, 1920. The ore consisted of chalcopyrite and iron sulphides in a silicious gangue.

Test work was conducted on this ore to see if it was adaptable to flotation using the Luckenbach re-agents instead of oil. The flotation concentrates being produced by oil flotation gave an analysis of 15 per cent to 20 per cent copper, and the Luckenbach re-agents were used to determine whether a higher grade product could be obtained with as good a recovery of the copper content.

Experimental work was carried on from February 11 to May 8, 1920. About thirty tests were conducted, and from these tests it was proven that by the use of the Luckenbach re-agents a higher grade concentrate could be produced than was being

obtained; but to obtain this high grade concentrate with a high recovery of the copper values, the cost of re-agents would be higher than the cost of oil. This higher cost may be balanced by the higher grade product, depending on the cost of marketing the concentrate.

The following is a description of some of the tests with the results obtained:—

Test No. 24.

Ore crushed in a jaw crusher, ground in Hardinge ball mill to 60 mesh, floated in Callow cells, making a rougher concentrate, and tailings to waste.

Crude ore	1·35% Cu
Concentrates	7·80% Cu
Tailings	0·28% Cu
Recovery	82·2 %

Test No. 25.

Four separate runs were made the same as Test 24, only pebbles instead of balls were used for grinding in the Hardinge mill.

	Run No. 1	Run No. 2	Run No. 3	Run No. 4
Crude ore	1·35% Cu	1·35% Cu	1·35% Cu	1·35% Cu
Concentrates	11·80% Cu	12·85% Cu	13·15% Cu	15·55% Cu
Tailings	0·08% Cu	0·15% Cu	0·13% Cu	0·15% Cu
Recovery	94·7 %	89·9 %	91·3 %	89·7 %

Test No. 27.

The rougher concentrates from the four runs of Test 25, were re-cleaned in the Callow cells.

Rougher concentrates	12·23% Cu
Cleaner concentrates	21·60% Cu
Tailings	1·60% Cu

This tailing would be considered a middling product and returned to the circuit in practice.

Test No. 26.

The same procedure as Test 25, with change in amounts of re-agents used.

Crude ore	1·35% Cu
Concentrates	23·85% Cu
Tailings	0·45% Cu
Recovery	67·9 %

Test No. 29.

Eight separate runs were made using varying amounts of re-agents. Balls were used for grinding instead of pebbles, otherwise runs same as Test 25.

	Run No. 1	Run No. 2	Run No. 3	Run No. 4
Crude ore	1·70% Cu	1·70% Cu	1·70% Cu	1·70% Cu
Concentrates	25·95% Cu	10·60% Cu	11·70% Cu	12·62% Cu
Tailings	0·40% Cu	0·32% Cu	0·20% Cu	0·14% Cu
Recovery	77·7 %	83·7 %	89·7 %	92·7 %
	Run No. 5	Run No. 6	Run No. 7	Run No. 8
Crude ore	1·70% Cu	1·70% Cu	1·70% Cu	1·70% Cu
Concentrates	8·40% Cu	11·55% Cu	8·10% Cu	13·85% Cu
Tailings	0·25% Cu	0·25% Cu	0·12% Cu	1·20% Cu
Recovery	87·9 %	87·1 %	94·4 %	32·2 %

Run No. 8 was made on some badly oxidized ore. This test shows that the Luckenbach re-agents cannot be used on this class of ore.

Test No. 30.

The concentrates from Test 29 were recleaned by passing them through the Callow cells.

Rougher concentrates	12·85% Cu
Cleaner concentrates	25·45% Cu
Tailings	6·40% Cu

The tailings would be considered a middling product and returned to the circuit in practice.

April 20, 1920.

Test No. 132

A shipment of approximately 1,000 pounds of gold ore was received from J. Myers, Esq., Winnipeg, Manitoba. This shipment was sent as a representative sample of the ore from the Bingo mine, the Pas District, Manitoba.

The ore consisted of white vein quartz, disseminated through which was small amounts of galena, sphalerite, chalcopyrite, and arsenopyrite. These sulphides and arsenides represent between one per cent and two per cent of the weight of the ore. Free gold was visible.

The object of the test work was to ascertain what recovery of the gold values could be obtained by amalgamation, and what further processes were necessary to recover the remaining values in the tailings after amalgamation.

The ore was crushed to 10 mesh, and a 14-pound sample cut out, which gave an assay of 4·22 ounces per ton.

Gross weight of ore received	992 pounds
Net weight of ore after crushing	967·5 "
Assay value per ton.....Au	4·22 oz.
Gold content in shipment	2·0414 oz.

Test No. 1.

A small preliminary test was made on the 14-pound sample which was crushed to 40 mesh and amalgamated with the following results:—

Before amalgamation.....Au	4·22 oz. per ton
After amalgamation.....Au	1·50 "
Recovery by amalgamation	64·5%

Test No. 2.

The remaining portion of the ore was crushed to pass 40 mesh, and amalgamated by passing it through an amalgamator and over plates. The tailings from amalgamation were run over a Wilfley concentrator. The results of this test were as follows:—

Net weight of ore treated	953·5 pounds
Assay value per ton.....Au	4·22 oz.
Gold content	2·012 oz.
Amalgamation and Concentration products—	
Bullion—fine gold from Test No. 2	2·066 oz.
Concentrates—11·5 lb.—assay 45·11 oz. per ton	0·259 "
Tailings—784·5 lb.—assay 0·59 oz. per ton	0·231 "
Total	2·556 "
Recovery by amalgamation	80·8%
Recovery by concentration	10·1%
Gold values in tailings	9·1%
Weight of bullion produced from shipment	2·403 oz.
Fineness	872·3
Fine gold in bullion, produced	2·096 "

SUMMARY

The amount of gold in the products is slightly greater than that figured from the original assay. This is due to the difficulty in getting an absolutely correct sample of the ore on account of the metallics encountered in grinding up the sample for assay.

The test shows that 80·8 per cent of the gold is recoverable by amalgamation; that 10·1 per cent of the gold is recoverable in concentrates, and 9·1 per cent still remains in the tailings. From previous work on this ore the greater proportion of what is left in the tailings can be recovered by cyanidation.

July 23, 1920.

Test No. 133

A carload shipment of molybdenite ore was received on April 3, 1920, from W. E. Joiner, Esq., 75 Sun Life Building, Toronto, Ont. The shipment was from his property on Lot 3, Concession XX, Township of Cardiff, Haliburton Co., Ontario.

The shipment represented a considerable tonnage of low grade ore from one portion of the property. Ore of a much better grade is supposed to have been found on another portion of the property. The low grade ore consisted of flake molybdenite up to half-inch in diameter, in a pyroxenite gangue rock.

Net dry weight of ore before treatment	59,026 pounds
Analysis—MoS_2	0·308%
Content—MoS_2	181·80 pounds

The ore was crushed in a jaw crusher to 1½ inch, sampled by passing through a Vezin sampler, the main flow going to a Hardinge ball mill, on to a Callow screen, the oversize being returned to the mill, the undersize to a Callow flotation unit.

The oil used was pine oil and coal oil, at the rate of ¾-pound per ton of crude ore treated.

The tailing assay showed	0·115% MoS_2
The concentrate produced gave an assay of	89·65% MoS_2
Recovery of molybdenite values	62·7 %

This ore was adaptable to the oil flotation process. The results show that a high grade concentrate can be made. The recovery was low, but in practice under good milling conditions this should be improved considerably and a very low tailing made.

June 15, 1920.

Test No. 134

A small sample of lead-zinc (sand-carbonate) ore weighing 5½ pounds, was received on April 6, 1920, from the Ptarmigan mines, Wilmer, B.C.

The ore consisted of galena, lead and zinc carbonates, and zinc silicate.

Small laboratory tests were made to obtain a separation of the lead and the zinc into different products of commercial value.

The sample as received was crushed to 40 mesh and sampled for analysis, which gave the following:—

Lead	Pb	24·30%
Zinc	Zn	21·40%
Iron	Fe	5·00%
Sulphur	S	1·04%
H_2O, CO_2, etc		11·50%
Silica	SiO_2	20·35%
Manganese	Mn	1·25%

The ore after the removal of the sample was screened on 100 mesh and each portion weighed, as follows:—

—40 +100	1,086 grams, representing 45·12%
—100	1,321 grams, representing 54·88%

Each of these sizes was sampled for analysis. The coarser material was then run over a laboratory Wilfley table using a sand deck, making a concentrate, middling and tailing. The fine material (—100) was run over the same table using a slime deck, making besides the concentrate, middling and tailing, a slime product, which was collected in a tank underneath the table. All the products were dried, weighed and sampled for analysis.

The results of the tests are given in the following table:—

+100 MESH MATERIAL

Product	Weight	% Pb.	% Zn.	Gms. Pb.	Gms. Zn.	% Pb. Value	% Zn. Value
Concentrate	260	69·50	7·65	180·7	19·9	71·1	7·1
Middling	302	18·40	34·05	55·6	102·8	21·9	36·5
Tailing	418	4·25	38·00	17·8	158·8	7·0	56·4
				254·1	281·5		
Heads	980	25·65	24·70	251·4	242·1	100·0	100·0

−100 MESH MATERIAL

Product	Weight	% Pb.	% Zn.	Gms. Pb.	Gms. Zn.	% Pb. Value	% Zn. Value
Concentrate	245	67·10	7·95	164·4	19·5	60·1	8·8
Middling	87	34·30	23·90	29·8	20·8	10·9	9·3
Tailing	403	8·10	27·75	32·6	111·8	11·9	50·2
Slime	281	11·55	18·30	32·5	51·4	11·9	23·1
Loss	197	7·21	9·69	14·2	19·1	5·2	8·6
Heads	1,213	22·5	18·35	273·5	222·6	100·0	100·0

SUMMARY AND CONCLUSIONS

The results of the laboratory test work show that the ore as submitted can be concentrated by gravity water concentration.

In the case of the coarser material, a high grade lead product, assaying 69·50 per cent lead, has been made with a recovery of 71·1 per cent of the lead values. This recovery would be increased by further treatment of the middling which contains 21·9 per cent of the lead values. A fair grade of zinc product, assaying 38·00 per cent zinc has been made, with a recovery of 56·4 per cent of the zinc values. This recovery would also be increased considerably by the retreatment of the middling product, which contains 36·5 per cent of the zinc values.

In the case of the fine material (—100 mesh) a high grade lead product assaying 67·10 per cent lead has been made, with a recovery of 60·1 per cent of the lead values. This recovery would be increased by further treatment of the middling product, which contains 10·9 per cent of the lead values. The zinc product is low grade, assaying only 27·75 per cent zinc, but with more careful manipulation of the concentrating machinery employed, the grade should be increased. The recovery of the zinc values is also low, namely 50·2 per cent, but this should also be increased by more careful manipulation of machinery.

From the results obtained on the small sample submitted a properly designed concentrating plant should give a lead product of grade 65 per cent Pb. with a recovery approaching 80 per cent of the lead values, and a zinc product of grade 35 per cent zinc, with a recovery approaching 70 per cent of the zinc values.

In the test work conducted, no attention has been paid to the silver values in the ore.

June 6, 1920.

Test No. 135

A shipment of 38 sacks of gold ore, net weight 2,572 pounds, was received from J. E. Cole, Esq., care A. G. Meindle, M.D., Winnipeg, Manitoba. The ore was from the Little Rice Lake district, Manitoba, and on examination was shown to contain chalcopyrite and some oxidized copper minerals, and iron pyrites in a quartz gangue. Free gold was visible in small amounts, but no free silver was noticeable.

The ore was crushed to ¼-inch size and cut down in a Jones riffled sampler, to a 35 pound sample for small test work. This 35 pound sample was further reduced by crushing to 30 mesh and sampled for assay, which gave the following:—

Gold	1.07 oz. per ton
Silver	1.07 " " "
Copper	1.43%

The test work conducted can be subdivided under the following heads:—

1. Amalgamation, tabling, and flotation.
2. Amalgamation, tabling, and cyaniding.
3. Straight flotation.
4. Amalgamation and tabling.
5. Amalgamation and flotation.

(1) Amalgamation, Tabling, and Flotation. (Small scale test.)

A small sample of 998 grams of the ore was cut from the 40 mesh sample and put in a pebble jar with 100 grams of mercury and 400 c.c. of water. The jar was rotated for three hours and the mercury was panned from the pulp. The amalgamation tailing was run over a small Wilfley table and a concentrate and tailing were made. The table tailing was ground wet to pass 100 mesh and floated in a laboratory Callow flotation machine, making a concentrate, a middling, and a tailing. The resultant products from this test were dried, sampled and assayed, giving results as shown in the following table:—

Product	Weight grams	Assay		Content		% of Values	
		Ozs. Au.	% Cu.	Au. Weight × Assay	Cu. grams	Au.	Cu.
Amalgamated	.....	.....	.....	899·10	.....	84·2	.....
Table concentrate	157	0·44	4·37	69·08	6·86	6·5	42·5
Flotation concentrate	55	0·38	12·42	20·90	6·83	2·0	42·3
Flotation middling	74	0·41	1·47	30·34	1·09	2·8	6·7
Flotation tailing	692	0·07	0·20	48·44	1·38	4·5	8·5
Ore	998	1·07	1·43	1,067·86	14·27	100·0	100·0

(2) Amalgamation, Tabling, and Cyaniding. (Small scale test.)

A small sample of 914 grams of the ore was cut from the 40 mesh sample and put in a pebble jar with 100 grams of mercury and 400 c.c. of water. The jar was rotated for three hours and the mercury panned from the pulp. The amalgamation tailing was run over a small Wilfley table, making a concentrate and tailing. The table tailing was ground wet to pass 100 mesh and treated with the cyanide solution. The result of this test work is given in the following table:—

Product	Weight grams	Assay		Content		% of Values	
		Ozs. Au.	% Cu.	Au. Weight × Assay	Cu. grams	Au.	Cu.
Amalgamated and cyanided	.....	.....	.....	893·34	.....	91·3	.....
Table concentrate	125	0·56	4·10	70·00	.....	7·2	.....
Cyanide tailing	732	0·02	0·95	14·64	.....	1·5	.....
Ore	914	1·07	1·43	977·98	.....	100·0	.....

(3) Straight Flotation. (Small scale test.)

A small sample of 885 grams of the ore was cut from the 40 mesh sample and further reduced to 100 mesh. It was then mixed with 1 c.c. of oil mixture—30 per cent hardwood oil, 15 per cent coal tar and 55 per cent tar creosote, and floated in the laboratory Callow flotation machine. A concentrate, middling and tailing were made. In crushing down the sample a small amount of metallics was caught on the screens. These were assayed separately. The results from this test are given in the table below:—

Product	Weight grams	Assay		Content		% of Values	
		Ozs. Au.	% Cu.	Au. Weight × Assay	Cu. gms.	Au.	Cu.
Metallics				172·78		27·9	
Concentrate	74	4·15	11·72	307·10	8·67	49·6	70·4
Middling	45	0·72	2·50	32·40	1·12	5·2	9·1
Tailing	766	0·14	0·33	107·24	2·53	17·3	20·5
Ore	885	1·07	1·43	946·95	12·66	100·0	100·0

(4) Amalgamation and Tabling. (Large scale test.)

The remaining portion of the ore not used in making the small scale tests was crushed to 40 mesh and run through an amalgamator and over plates. The tailing from amalgamation was sampled and the remaining portion after sampling run over a Wilfley table, making a concentrate and tailing. The results of this test work are shown in the following tables:—

AMALGAMATION TEST

Product	Weight pounds	Assay			Content			% of Values		
		Ozs. Au.	Ozs. Ag.	% Cu.	Ozs. Au.	Ozs. Ag.	Lbs. Cu.	Au.	Ag.	Cu.
Metallics					·0647			6·4		
Amalgam					·5683	0·3284		55·8	18·2	
Tailing	2,484·5	0·31	1·19	1·43	·3851	1·4783		37·8	81·8	
Ore	2,484·5	1·07	1·50	1·43	1·3292	1·8634		100·0	100·0	

TABLE TEST ON AMALGAMATION TAILING

Product	Weight pounds	Assay			Content			% of Values		
		Ozs. Au.	Ozs. Ag.	% Cu.	Ozs. Au.	Ozs. Ag.	Lbs. Cu.	Au.	Ag.	Cu.
Concentrate	171	3·06	12·40	15·30	·2616	1·060	26·16	66·0	91·7	74·4
Tailing	1,924	0·14	0·10	0·25	·1347	·096	4·81	34·0	8·3	13·7
Loss	363·5			1·15			4·19			11·9
Amalgamation tailing	2,458·5	0·31	1·19	1·43	·3810	1·463	35·16	100·0	100·0	100·0

These results show the following recoveries:—

	By Amalgamation	In Concentrates	Total Recoveries	Loss in Tailing
	%	%	%	%
Au	62·2	25·0	87·2	12·8
Ag	18·2	75·0	93·2	6·8
Cu	None	74·4	74·4	25·6

The amalgam from this test from the clean up of the plates was retorted and reduced to bullion with the following weight and fineness:—

Weight of bullion	28·2312 grams	0·9077 ozs.	18·15 dwts.
Fineness	Au. 633·3	Ag. 366	Cu. trace

(5) Amalgamation and Flotation. (Large and small scale tests.)

A sample of the amalgamation tailing from test No. 4 was ground wet in a pebble jar to 100 mesh, mixed with 1 c.c. of oil mixture as per test No. 3 and floated in the laboratory Callow flotation machine, with the following results:—

Product	Weight grams	Assay			Content			% of Values		
		Ozs. Au.	Ozs. Ag.	% Cu.	Au. Weight × Assay	Ag. Weight × Assay	Cu. gms.	Au.	Ag.	Cu.
Concentrate	84	1·48	11·12	12·70	124·3	934·1	10·67	53·5	95·8	72·5
Middling	67	1·00	0·37	4·20	67·0	24·8	2·81	28·8	2·5	19·1
Tailing	825	0·05	0·02	0·15	41·2	16·5	1·24	17·7	1·7	8·4
Amalgamation tailing	976	0·31	1·19	1·43	302·6	1,161·4	13·96	100·0	100·0	100·0

These results show the following recoveries:—

	By Amalgamation	In Concentrate and Middling	Total Recoveries	Loss in Tailing
	%	%	%	%
Au	62·2	31·1	93·3	6·7
Ag	18·2	80·4	98·6	1·4
Cu	None	91·6	91·6	8·4

SUMMARY AND CONCLUSIONS

The results of the above test work show that the ore as submitted is amenable to treatment. Over 60 per cent of the gold values can be recovered by amalgamation, but a very small percentage of the silver values is recoverable by this method. The silver must, therefore, be for the most part in the form of the sulphide, and tabling or flotation is necessary to recover the silver and copper values. To make a high recovery of the silver and copper values and the remaining gold values after amalgamation, a combination of tabling and flotation would give the better results.

By amalgamation, tabling, and flotation, it is possible to make a 95 per cent recovery of the gold and silver values, and a 90 per cent recovery of the copper values in the ore.

From the above tables the concentrate from tabling and flotation would carry the greater proportion of the silver and copper values of a grade—gold, 3 ounces—silver, 12 ounces—and copper, 15 per cent. This would be an ideal shipping product for the smelters.

October 4, 1920.

Test No. 136

A shipment of 2,000 pounds of strontium ore was received June 21, 1920, from Heber Bambrick, Esq., Calabogie, Ontario.

This shipment represented a considerable tonnage of mixed celestite and gangue which requires concentration to remove the gangue and furnish a high grade celestite product. The gangue material is a light brownish calcite.

In conducting the concentration tests on this ore it was thought advisable to obtain as much clean celestite as possible in a coarse form, and as the celestite crushed much more easily than the gangue, care was taken in the crushing so as to make a minimum amount of fines.

The ore was crushed to 2 inches in a jaw breaker and run over a Ferraris screen fitted with 1-inch and ¼-inch screens. A head sample was cut out by a Vezin sampler, through which the flow passed onto the screen. The oversize + 1 inch was run over a picking belt and the clean celestite picked out. The + 1 inch was then returned to the rolls and crushed to pass the 1-inch screen. From the above operation the following products were obtained:—

Product	Weight lbs.	Analysis %		Content lbs.		% of Values	
		Ba & $SrSo_4$	$CaCo_3$	Ba & $SrSo_4$	$CaCo_3$	Ba & $SrSo_4$	$CaCo_3$
Handpicked	163	89·52	9·50	145·9	15·5	16·5	2·0
1 inch	802	35·62	58·88	285·7	472·2	32·3	60·7
¼ inch	741	57·83	36·60	428·5	271·2	48·5	34·8
Dust loss	43·5	54·25	45·06	23·6	19·6	2·7	2·5
Ore	1,749·5	50·51	44·50	883·7	778·5	100·0	100·0
Head sample	205·0	50·51	44·50	.....	.....	.....	.....
To crusher	1,954·5	50·51	44·50	.....	.....	.....	.....

Both the one-inch and quarter-inch products were concentrated by passing them through a James jig.

JIG TEST ON QUARTER-INCH PRODUCT

Products	Weight lbs.	Analysis %		Content lbs.		Percentages of Values			
						Ba & $SrSO_4$		$CaCO_3$	
		Ba & $SrSO_4$	$CaCO_3$	Ba & $SrSO_4$	$CaCO_3$	¼"	Crude	¼"	Crude
Concentrate No. 1 Jig	25·5	91·40	5·85	23·3	1·5	5·7	2·8	0·6	0·2
Concentrate No. 2 Jig	77	92·06	4·31	70·9	3·3	17·4	8·4	1·3	0·4
Concentrate table	287	83·48	14·73	239·6	42·3	58·6	28·4	16·3	5·7
Tailing—Table	2·5	38·07	54·09	1·0	1·4	0·2	0·1	0·5	0·2
Tailing—Jig	275	22·59	71·40	62·1	196·3	15·2	7·4	75·5	26·3
Jig bed	20	60·32	33·07	12·1	6·6	.....	.....	.....	.....
Slime loss	41	29·27	36·59	12·0	15·0	2·9	1·4	5·8	2·0
Totals	728	57·83	36·60	421·0	266·4	100·0	48·5	100·0	34·8

NOTE—The Hutch products from the Jig were tabled to determine whether they could not be improved. Results were unsatisfactory. With the jigs in proper adjustment, a 90 per cent Hutch product should be made. The small amount run through the jig did not allow proper adjustment to be made.

JIG TEST ON ONE-INCH PRODUCT

Products	Weight lbs.	Analysis %		Content lbs.		Percentages of Values			
						Ba & $SrSO_4$		$CaCO_3$	
		Ba & $SrSO_4$	$CaCO_3$	Ba & $SrSO_4$	$CaCO_3$	1″	Crude	1″	Crude
Concentrate No. 1 Jig	51·5	91·73	6·32	47·2	3·3	18·3	5·9	0·7	0·4
Concentrate No. 2 Jig	86	90·33	8·19	77·7	7·0	30·1	9·7	1·6	1·0
Hutch No. 1 Jig	59·5	86·20	12·20	51·3	7·3	19·8	6·4	1·7	1·0
Hutch No. 2 Jig	10	76·88	20·64	7·7	2·1	3·0	1·0	0·5	0·3
Tailing—Jig	506	14·72	79·38	74·5	401·7	28·8	9·3	92·0	55·9
Jig bed	22	56·40	40·38	12·4	8·9	.....	.....	.....	.....
Slime loss	22	0·00	70·00	0·0	15·4	.....	.....	3·5	2·1
Totals	757	35·62	58·88	269·6	445·7	100·0	32·3	100·0	60·7

SUMMARY OF PRODUCTS

Product	Analysis % Ba & $SrSO_4$	Percentage of total Ba & $SrSO_4$
Handpicked	89·52	16·5
Concentrate Jig No. 1—½″	91·40	2·8
Concentrate Jig No. 2—½″	92·06	8·4
Table Concentrate—¼″	83·48	28·4
Concentrate Jig No. 1—1″	91·73	5·9
Concentrate Jig No. 2—1″	90·33	9·7
Hutch Jig No. 1—1″	86·20	6·4
Hutch Jig No. 2—1″	76·88	1·0
Total Recovery	.....	79·1

CONCLUSIONS

Handpicking should be resorted to as the celestite breaks away quite freely from the gangue, and a clean celestite product can be obtained representing 16·5 per cent of the values.

By jigging the 1-inch and ¼-inch material after handpicking, the jig concentrates obtained were equally as good as the handpicked product, and with careful manipulation of the jigs, after obtaining the proper adjustments, a hutch product should be made practically as good as the concentrates.

The recovery on an ore of the grade submitted should be between 75 per cent and 80 per cent.

September 10, 1920.

Test No. 137

A small shipment of 100 pounds of gold ore was received July 29, 1920, from the Golden Summit Mining Company, Ltd., Sesikinika, Ontario.

The ore contained free gold with small amounts of iron and copper sulphides. Telluride was also supposed to be present.

The shipment was crushed down to ¼ inch and a 6·25 pound sample was cut out for assay and preliminary test work.

The assay of the shipment showed it to contain:—

Gold	2·73 oz. per ton
Silver	0·18 "
Copper	0·06%

A series of small laboratory tests were made to obtain its adaptability to amalgamation, concentration and cyanidation.

Test Run No. 1

Amalgamation.—Six pounds of the ore was crushed to 40 mesh and amalgamated by mixing in a pebble jar with 10 per cent by weight of mercury. The mercury was panned from the pulp and the tailing assayed.

Before amalgamation..	Au—2·73 oz.	Ag—0·18 oz.
After amalgamation..	Au—0·20 "	Ag—0·08 "
Recoveries..	Au—92.6%	Ag—55.5%

This test gives the total amount that could be amalgamated under the best conditions.

Concentration.—A small amount of the tailing from amalgamation was run over a Wilfley table, where a concentrate and tailing were made. The concentrate gave an assay of Au — 7·10 oz : Ag — 1·22 oz, and the tailing Au — trace — an almost complete separation of the gold values.

A 500-gram sample of the tailing from amalgamation ground to 100 mesh and run through a laboratory flotation machine gave similar results.

Cyanidation.—A sample of the tailing from amalgamation ground to 100 mesh was cyanided in 0·17 per cent solution, giving a tailing assay of Au — trace, an almost complete separation of the gold values remaining after amalgamation.

Test Run No. 2

Amalgamation.—The remainder of the ore, 93 pounds, was crushed to 40 mesh and run through an amalgamator over plates. The amalgam was collected, retorted and the sponge refined. The tailings were sampled and assayed:—

Before amalgamation..	Au—2·73 oz.	Ag—0·18 oz.
After amalgamation..	Au—0·62 "	Ag—trace
Recoveries..	Au—77·3%	Ag—practically a total

Bullion recovered from amalgam—3·0772 grams=1·98 dwts.=0·099 oz.

This test gives the recovery that could be expected in milling practice on this class of ore, which is between 75 per cent and 80 per cent of the gold values in the ore.

Concentration.—82·5 pounds of the tailings from amalgamation were run over a large Wilfley table and three products were made as follows:—

Concentrate..	Weight	6 oz.	Assay	Au—49·8 oz.
Middling..	"	8·5 lb.	"	Au— 2·5 "
Tailing..	"	56 lb.	"	Au—trace

This test shows practically a complete recovery of the gold values remaining in the amalgamation tailing.

A flotation test on the tailings from amalgamation ground to 100 mesh gave similar results.

Cyanidation.—A number of cyanide tests were made on the tailing from amalgamation with results that no assay of the cyanide tailing gave over a trace of gold, showing an almost complete recovery of the gold values remaining in the tailing from amalgamation.

A cyanide test was made on the middling from the Wilfley table which assayed 2·50 oz. in gold, with similar results.

CONCLUSIONS

The ore, as submitted for test purposes, is amenable to treatment, 75 per cent to 80 per cent of the values can be recovered by amalgamation, and an almost complete recovery made of the values remaining by concentration or by cyanidation.

December 31, 1920.

Test No. 138

Three samples of tin barilla weighing about ten pounds each were received at the Ore Dressing and Metallurgical Laboratories on May 25, 1920, from Mr. H. G. Cobb of the Electro-Tin Products, Limited, Brantford, Ont. These samples were marked Nos. 51, 55 and 59, and consisted of cassiterite and impurities in the form of a number of different sulphides and arsenides.

Test work was carried out only on sample No. 51, which was first ground to 60 mesh and a sample cut out, which gave the following analysis:—

Sn	59·90%
Sb	trace
Bi	1·15%
Fe	5·60%
Cu	trace
As	0·49%
S	4·98%
SiO_2	7·35%

The object of the test work was to remove the impurities and raise the grade of the barilla, thereby obtaining a more desirable product for reduction to tin metal. As the impurities were for the most part in the form of sulphides, it was thought possible that they could be floated from the barilla by flotation.

Two small tests were made on the laboratory Janney flotation machine, the results of which are tabulated below:—

Test No. 1—Using hardwood creosote, coal tar, and coal tar creosote.

Product	Weight grams	Analysis Percent					Content gms Sn	Percentage of Sn values
		As	S	Bi	Fe	Sn		
Floated	144	0·83	13·20	3·65	11·50	44·00	63·36	20·9
Unfloated	356	0·36	1·60	0·08	3·50	67·40	239·94	79·1
Heads	500	0·49	4·98	1·15	5·60	59·90	299·50	100·0

Test No. 2—Using pine oil, crude turpentine, and coal oil.

Product	Weight grams	Analysis Percent					Content gms. Sn.	Percentage of Sn values
		As	S	Bi	Fe	Sn		
Floated	118	1·23	12·90	3·90	11·40	31·45	37·71	12·7
Unfloated	382	0·27	2·55	0·24	3·55	66·75	254·98	87·3
Heads	500	0·49	4·98	1·15	5·60	59·90	299·50	100·0

CONCLUSIONS

The results of the above tests show that the impurities can be removed to a large extent by flotation, and with further experimental work on the reagents to be used, much better results could be obtained. Although a considerable proportion of the tin values floated with the impurities, by regrinding and floating, using other reagents, the greater proportion of this would likely be recovered. A higher grade tin product could also be made by refloating.

December 31, 1920.

Test No. 139

A 32-pound sample of graphite ore was received on November 15, 1920, at the Ore Dressing and Metallurgical Laboratories from Mr. H. P. H. Brumell, Buckingham, Que. The shipment was made from Waltham, Que., from an occurrence on Lot 27, Range B, Bryson township, Pontiac county, Quebec, and consisted of flake graphite of a fair size in a gneiss-like gangue.

A concentration test was desired to obtain a high recovery of the graphite in the form of a high grade flake, without injuring the flake to any appreciable extent.

The whole sample was crushed to pass 10 mesh, and a sample cut out for analysis, which showed it to contain 2·50 per cent carbon.

A test was conducted on the laboratory flotation machines, the Ruth and the Janney, and on the laboratory Wilfley table, to determine the grade of concentrate that could be produced from the ore and the recovery of the graphitic content.

Five lots of the ore, ground to pass 10 mesh, each of 500 grams, were floated in the laboratory Ruth flotation machine, making a concentrate and tailing. The concentrates were mixed and the tailings mixed, so as to obtain sufficient products for further treatment. The concentrates were screened on a 100 mesh screen. The + 100 mesh concentrate was tabled on a laboratory Wilfley concentrator, making a concentrate and a tailing, and the — 100 mesh material was floated in a laboratory Janney flotation machine, making a concentrate and tailing.

The following table shows the products, and results of this test:—

Product	Wt. grams	% C.	Grams C.	% C. value
Table concentrate	53	85·30	45·21	76·0
Janney concentrate	28	11·00	3·08	5·2
Table tailing	33	10·30	3·40	5·7
Janney tailing	34	·90	·31	·5
Ruth tailing	2,352	·32	7·53	12·6
			59·53	
Heads	2,500	2·50	62·50	100·0

CONCLUSIONS

The shipment was very low grade, 2·50 per cent carbon, and under present conditions could not be worked commercially.

The results of the test work showed that the ore, as represented by this shipment, is very amenable to concentration, that a high grade flake could be produced with a high recovery of the carbon values in the coarse flake.

The Janney concentrates and table tailings would be returned to the circuit in milling operations, and a percentage of their carbon values recovered in the form of a higher grade product.

December 31, 1920.

Test No. 140

A carload of copper ore, shipping weight 50,760 pounds, was received September 4, 1920, at the Ore Dressing and Metallurgical Laboratories from the Granby Consolidated Mining, Smelting & Power Co., Anyox, B.C. The ore was a representative shipment of their low grade Hidden Creek No. 2, and consisted of chalcopyrite and pyrite in a greenstone gangue.

Concentration tests were desired to determine its adaptability to flotation by the various processes; to make a high grade concentrate with a high recovery of the copper values. To accomplish this necessitated a selective separation of the copper and iron sulphides.

During the latter part of the year a number of small scale tests and seven larger scale tests were made on the pneumatic and mechanical agitation type of flotation machines, using flotation reagents such as oil, Luckenbach reagents, and X-Y reagents.

The results obtained to date have been good, showing that the ore can be successfully concentrated. Further work is being carried on and the results of comparative tests will be embodied in a report as soon as completed during the following year.

December 31, 1921.

OTHER TEST WORK

A sample of graphite concentrates was received from the Quebec Graphite Company, Buckingham, Quebec, March 18, 1920, for the purpose of conducting some grinding tests using a disc pulverizer. It was found that this method of grinding and pulverizing was inefficient.

On October 11, 1920, several samples of graphite mill products were received from the Timmins graphite mine, Stanleyville, Ontario. Table tests were desired on these products to obtain data as to the use of tables in connexion with the flotation of graphite in their mill.

A number of samples of shale and clay were prepared for the Ceramic Division.

Samples of barite and serpentine were received from W. D. Holmes, Esq., Ottawa, for grinding tests, to obtain a suitable product for the market.

A small sample of allanite was received June 24, 1920, from the Mineralogical Division, Geological Survey, Department of Mines. Table tests were made on this sample and the products returned for investigation and analysis.

Two carloads of phonolite rock were received on August 24, 1920, and September 9, 1920, from the Dominion Glass Company, Montreal, Quebec. The first shipment consisted of 68,813 pounds, and the second of 55,534 pounds. It was desired that the rock be crushed to 8 mesh, making the minimum amount of fines. The crushed rock was to be used for the continuation of experimental work being carried on by the Dominion Glass Company, in the manufacture of their products.

FUELS AND FUEL TESTING DIVISION

I

GENERAL REVIEW OF INVESTIGATIONS

B. F. Haanel

Chief of Division

The Fuels and Fuel Testing Division has been engaged during the fiscal year 1919-20, on research work which has been in progress for some years, the results of which are not yet ready for publication; also on certain investigations, the results of some of which are sufficiently far advanced for publication in preliminary form. The research work on oil-shales, lignitic coal, and peat, will, it is hoped, be ready for publication at the end of 1921. The determinations of oil in the several samples of oil-shales submitted to the laboratory for investigation, by Dr. W. J. Wright—who, before he severed his connexion with the Department of Mines, was engaged in investigating the oil-shale formations of New Brunswick, Nova Scotia, and elsewhere —are not yet complete.

The report on the special investigations of lignites, conducted by the staff of the Fuels and Fuel Testing Division, in co-operation with the Lignite Utilization Board, which were begun by Edgar Stansfield and R. E. Gilmore, in 1919, is in course of preparation by Mr. Stansfield, and will, it is hoped, be published in the near future.

II

CARBONIZATION OF PEAT

Edgar Stansfield and J. H. H. Nicolls

In conjunction with the small scale carbonization experiments on samples of lignite from Saskatchewan and Alberta[1], a similar series was carried out on peat from the bog at Alfred, Ontario. The finely ground peat was moulded, in a hand press, into cylindrical briquettes, ¼-inch diameter and about ¼-inch long, which ran about 6 or 8 to the gram. These were stored in glass stoppered bottles, under which conditions the moisture was found to remain almost unchanged for a period of four or five weeks. The moisture content, 25 per cent, represents the average moisture content of peat as it comes on the market.

The apparatus employed was similar to that described on page 90 of the Summary Report[1] for 1918, an excerpt from which follows:—

"The apparatus used in the experiments consisted of a cylindrical iron retort 1½ inches high and 1½ inches diameter, inside measurement, having a lid which was held on by a small clamp, the joint being rendered air-tight by means of an asbestos gasket. A small inlet tube was screwed into the bottom of the retort, and an outlet tube into the lid; the inlet and outlet tubes being so arranged that the retort could be completely immersed in an oil or lead bath.

"The briquettes employed in each test were weighed out into a 10 gram capacity quartz crucible which fitted inside the iron retort. The heating was done by immersing the retort in a bath, which for tests up to 300° C. was of oil, and for those above that temperature of lead. The lead was contained in a 4-inch length of 4-inch iron pipe with a cap end, and was heated in a gas-fired furnace which gave a very uniform temperature throughout the bath, and which permitted of rapid heating and easy control. The temperature was followed by pyrometers immersed in the lead.

[1] Mines Branch Summary Reports—1918, p. 90—1919, p. 30.

"Procedure.—The general procedure, modified in the particular cases noted, was as follows. From 3 to 10 grams of the briquetted sample was weighed out into the quartz crucible, this was placed in the iron retort and the top clamped down. A gentle stream of dry coal gas was passed in through the inlet tube to displace the air, the gas was then cut off and the retort immersed in the bath of oil or lead, previously heated to almost the desired temperature. The progress of carbonization was watched by causing the evolved gas to bubble through a little water; it was thus found that 1½ hours was sufficient to complete the operation. In every case after the lead bath had been finally adjusted to the desired temperature, this temperature was maintained for at least half an hour. At the end of the experiment the retort was taken out of the bath and cooled as rapidly as possible, cold water being run over it to complete the cooling. When quite cold the retort was opened and the quartz crucible weighed to determine the loss in weight of the briquettes during the experiment. The calorific value of the carbonized briquettes was then determined by means of a Riche adiabatic calorimeter using a platinum resistance thermometer. Ash and volatile matter determinations were also made.

"It was found necessary to standardize the conditions, especially the time factor, in all operations with the dried or carbonized residue. The quartz crucible and contents were always weighed in a stoppered weighing bottle, and the portion required for the calorimeter was weighed out by difference as nearly as possible fifteen minutes after stopping the heating."

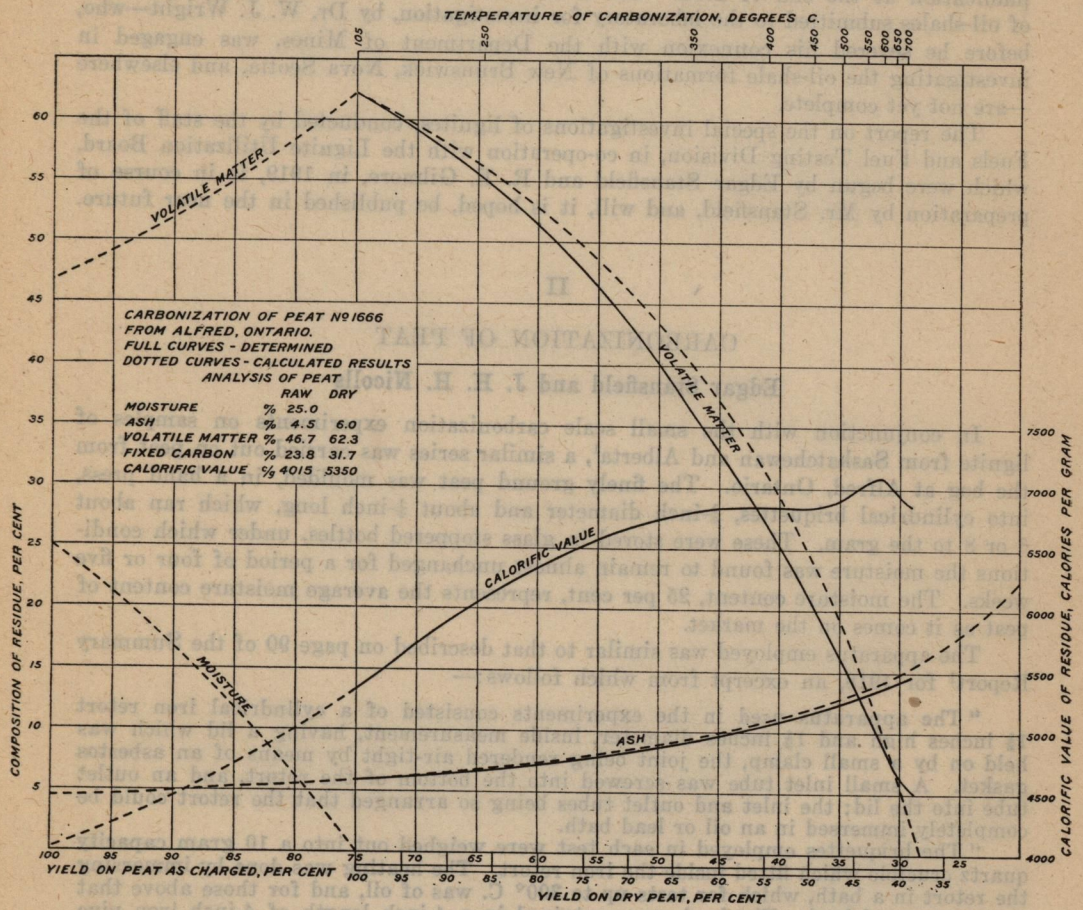

Fig. 2.

The results of the experiments are shown graphically in Fig. 2, while Table I, which is derived from the rounded curves in the diagram, indicates the results obtainable from the carbonization of dry peat.

It will be observed that the calorific value rises very greatly with the temperature of carbonization, the maximum percentage increase being 32·5, at 600°, as against an increase of 20·5 in the case of Shand lignite, these values having been calculated on the basis of the dried fuel. This increased calorific value is obtained only after 58 per cent of the dry, or 68 per cent of the raw peat has been driven off, so that, at least without a high yield of valuable by-products, the distillation would be inefficient.

However, the calorific value of peat increases rapidly at temperatures below 350°, a large amount of volatile incombustible matter being driven off, in which respect it differs materially from the lignites, so far examined. From 375° to 450° the calorific value remains practically constant, so that carbonization at 400°, with a yield of 55 differs materially from the lignites so far examined. From 375° to 450° the calorific value of 27·9, would probably be more efficient than at 600°. To illustrate this, and in order to compare the products of carbonization of peat with those obtained from lignite, Table II has been drawn up.

In view of the exceptionally high percentage of distillates, it is obvious that a study of the carbonization of peat is incomplete without the determination of the by-products. Accordingly, a series of large scale laboratory experiments[1] will shortly be carried out on the carbonization of peat and of certain of the Alberta lignites. This will presumably be followed by still larger scale experiments, in order to obtain the most complete information possible.

TABLE I

Temperature of carbonization, degrees C.	Yield of residue	Analysis of residue			
		Calorific value, calories per gram	Ash	Volatile matter	Fixed carbon
105°	100·0%	5350	6·0%	62·3%	31·7%
250°	86·0%	6090	6·7%	55·1%	38·2%
280°	77·8%	6400	7·3%	49·9%	42·8%
350°	63·3%	6800	9·2%	36·3%	54·5%
400°	54·9%	6840	10·7%	26·7%	62·6%
450°	49·7%	6850	11·6%	20·0%	68·4%
500°	46·3%	6910	12·5%	15·8%	71·7%
550°	44·0%	7030	13·1%	12·3%	74·6%
600°	42·1%	7090	13·6%	9·7%	76·7%
650°	40·6%	6990	14·0%	7·0%	79·0%
700°	39·3%	6900	14·4%	5·6%	80·0%

[1] Summary Report, 1918, p. 99.

TABLE II

Fuel	C.V. of dry coal, calories per gram	Yield* at 400°C.	C.V. of residue at 400°C.	Percentage increase C.V. at 400°C.	Optimum[1] temperature degrees C.	Yield* at op. temp.	C.V. of residue at op. temp.	Percentage increase C.V. at op. temp.
Alfred peat	5350	55%	6840	27·9	600°	42%	7090	32·5
Saskatchewan Coal, Brick and Power Co., Shand, Sask.	6250	80%	7120	13·9	570°	66%	7530	20·5
West Dominion Collieries, Taylorton, Sask.	6050	79%	6650	9·9	560°	66%	7050	16·5
Cardiff Collieries, Ltd., Cardiff, Alta.	6100	83%	6700	9·8	620°	67%	7130	16·9
G. W. Coal Co's. Black Diamond mine, Clover Bar, Alta.	6390	83%	6970	9·1	600°	67%	7470	16·9
Tofield Coal Co's. mine, Tofield, Alta.	6480	84%	6960	7·4	600°	67%	7460	15·1
Halbert's mine, Trochu, Alta.	6430	84%	6730	4·7	630°	71%	7170	11·5

*Yields indicated are those from dried fuel.
[1] Temperature at which highest calorific value is obtained.

III

NOTES ON THE HOFFMANN POTASH TEST

J. H. H. Nicolls

A previous report,[1] described the application of the Hoffmann Potash Test to the classification of coals. It was shown that the usual test with boiling potash solution, whilst providing a broad general classification, made insufficient distinction between the various lower grade coals and lignites. The cold test, on the other hand, made a distinction, but required too much time for practical purposes.

The writer recently attempted to work out a modified test, which would further differentiate between the various lower grade coals. The following methods were tried: (1) dilution of the solution, obtained by boiling ½ gram of coal with the standard potash solution (as in the general test), with definite volumes of water; (2) boiling ½ gram of coal with standard potash solution diluted with 1 or more volumes of water; (3) boiling $\frac{1}{10}$ gram of coal with standard potash; (4) boiling $\frac{1}{10}$ gram of coal with standard potash diluted with one or more volumes of water; and (5) determining what dilution of standard potash solution was necessary, in order to produce a certain definite colour, on boiling with a particular coal.

Each of these methods indicated distinct differences between the low grade coals, but unfortunately the results obtained by one method did not always place the coals in the same order as did those from another. It was also observed that the effect of the potash upon two samples from the same locality were sometimes markedly different. Contrary to expectation, it was found that dilution of the potash, up to a certain limit, increased its action on the coal. The accompanying table shows that the results obtained by boiling $\frac{1}{10}$ gram of coal with the standard solution proved the most satisfactory.

In referring to the table it should be noted that (1) all the coals with the exception of the Shand are from Alberta; (2) the moisture on the Shand coal, air dried, is the average obtained from the analyses of several samples from the same locality, the 'split volatile' ratio being derived from an analysis calculated on the basis of this moisture, while the carbon-hydrogen ratio is from the analysis of a sample taken from the Shand mine at almost the same time as No. 973; (3) "moisture + ½ volatile matter"; and (4) "1:0" indicates standard potash solution, sp. gr. 1·12, and "1:4", "1:50", indicate standard potash diluted with 4 and 50 volumes, respectively, of water.

It was observed that, in the case of certain of the more dilute solutions which filtered slowly, the filtrate which passed through the paper after the potash had been in contact with it for 15 or 20 minutes, contained a cloud of fine black particles, and that a small quantity of these particles was sufficient to obscure the brown colour of the bulk of the filtrate. This suggested that the potash, being longer than usual in contact with the coal, attacked it more than in the usual test, or that it attacked the paper and allowed very fine particles of coal to pass through it.

The second of these hypotheses seemed the more likely, and this further suggested that a certain amount of colour might be produced when the potash attacked the paper. Accordingly, several kinds of filter paper were boiled with both strong and dilute potash solution, with resultant yellow colours. In most cases these were not dark enough to have any effect on the colours from the lower grade coals, but would probably obscure them from the high grade ones. Care should, therefore, be taken in the choice of filter paper. Furthermore, when dilute solutions are employed, only the filtrate which passes through the paper during the first 15 minutes of filtering (in most cases this is fully three-quarters of the filtrate) should be considered.

Certain points in the former paper may perhaps be a little indefinite. In the first place; by 'ferric chloride' is meant the hydrated salt with 6 molecules of water. In the second place; it should be distinctly understood that the undiluted solution of ferric chloride, etc., is No. 1 of the Hoffmann series.

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[1] Mines Branch Summary Report, 1916, p. 65.

TABLE I

Sample number	Locality	Calories per gram, ash and moisture free coal	Moisture, air dried coal	Carbon-hydrogen ratio, air dried coal	Fuel ratio	"Split volatile" ratio, air dried coal.	Boiling with "1:0", original series	"Cold test" with "1:0"	"Boiling with "1:0", recent series	Filtrate from last test with 20 vols. water	Boiling with "1:50"	1-10 gr. boiling with "1:0"	1-10 gr. boiling with "1:4"	1-10 gr. boiling with "1:50"
720	Saunders Creek	7470	8·5	13·4	2·05	3·2	(4–5)	7	(5–4)	8	.....	(7–6)	.....	.....
321	Lethbridge	7440	8·8	11·8	1·40	2·5	3	(6–5)	.....	.....	.....	6	.....	.....
306	"	7510	8·9	11·6	1·40	2·5	(3–2)	.....	.....	.....	.....	(5–6)	.....	.....
722	"	7250	9·3	11·5	1·80	2·7	(3–2)	.....	(3–4)	(7–8)	5	(5–6)	.....	.....
406	Taber	7230	14·0	10·5	1·45	2·1	(1–2)	4	.....	.....	.....	(3–4)	.....	.....
407	"	7010	12·4	10·6	1·55	2·2	(1–2)	.....	.....	.....	.....	(3–4)	.....	.....
682	Cardiff	6700	18·9	9·3	1·50	1·7	(1–2)	4	.....	.....	.....	(3–4)	.....	.....
358	Evansburg	6750	.....	.....	1·60	.....	.....	.....	1	(5–6)	(2–3)	(4–3)	(3–2)	(3–4)
916	Hanna	6760	21·2	8·9	1·35	1·5	1	.....	1	(5–4)	(2–1)	(3–2)	(2–1)	(2–3)
665	Rosedale	7250	13·9	11·3	1·40	2·1	1	(4–3)	1	(5–6)	(3–2)	3	(2–3)	(4–3)
1505	Edmonton	6890	.....	.....	1·50	.....	.....	.....	1	(5–6)	3	3	(2–3)	(3–4)
680	"	6810	17·3	10·3	1·70	2·0	1	3	.....	.....	.....	(3–2)	.....	(3–2)
1507	Tofield	7000	.....	.....	1·35	.....	.....	.....	(1–2)	6	(3–2)	4	3	4
180	"	6930	15·9	10·1	1·30	1·9	1	(3–2)	.....	.....	.....	(2–3)	.....	(2–1)
973	Shand	6760	27·0	7·9	1·20	1·2	.....	.....	1	(5–4)	1	(2–3)	1	1

IV

TRENT PROCESS FOR PURIFYING COAL HIGH IN ASH

B. F. Haanel

On November 25, 1920, the writer visited the experimental plant of the Trent Process Corporation, Washington, D.C., U.S.A., to witness the tests which were being conducted, according to their process, on several samples of Canadian coals, high in ash. The experimental laboratories of the Trent Process Corporation are located on ground adjacent to the United States Bureau of Standards, which Bureau, the writer was informed, co-operated with this Corporation in conducting certain investigations.

DESCRIPTION OF PROCESS

The reduction of the ash content of a coal high in ash, depends upon the selective affinity of oil for the carbonaceous matter in coal, and of water for the mineral ash content. In order to obtain a good separation of the mineral matter of the coal, and at the same time a complete agglomeration of the carbon matter with the oil, it is necessary to crush the coal to about 200 mesh. Coal of this fineness, mixed with a large amount of water, is placed in a churn, similar to a churn for making butter, in which it is thoroughly agitated, oil being slowly admitted during the period of agitation. The quantity of oil required, while not the same for every coal, is in the neighborhood of 40 to 45 per cent by weight, of the coal treated. When the mixture of oil, water, and finely divided coal, is briskly agitated, the oil and the carbon begin to agglomerate, and the ash settles in the water. When the action is complete, a separation of the oil and carbon, in small globules, and the water containing the mineral ash content, is very marked. The time required for making the separation varies with different coals. With certain of the coals treated, the time required did not exceed two to three minutes; while with other coals fifteen or more minutes were required to obtain a complete separation. In the case of lignites, however, the time required to obtain an agglomeration of the carbon and oil has been as long as 9 hours; for example, the time required to obtain an agglomeration of the carbon and oil of a sample of lignite from North Dakota was nine hours. Complete agglomeration, however, was obtained in a much shorter time with a sample of lignite from the Shand mine, Saskatchewan, namely, 25 minutes. The details of this test will be found on page 51. The tests on the samples of coal which the writer had sent to the Trent Process Corporation laboratories, from British Columbia, Alberta, Saskatchewan, and Nova Scotia, were conducted in small laboratory apparatus, and not in their large semi-commercial plant. Such separations as were made at Washington, can be made in any laboratory, by simply putting the pulverized coal, water, and oil, in a small butter churn, or a large size churn for whipping cream. This latter, is usually made of glass, and would permit the agglomeration of the oil and the separation of ash to be seen. While the writer was in their laboratories, he witnessed large samples of coal being treated in a semi-commercial plant. This plant consists of a specially designed mill for pulverizing the coal to 200 mesh, and an agitator, or as it is called at the plant, an "amalgamator," of large size, into which the pulverized coal and oil are automatically fed. The specially designed pulverizing mill employed at this plant, and which will be employed in the commercial plants the Trent Process Corporation contemplate erecting, consists of seven horizontal steel cylinders, Fig. 3, bound together by iron hoops, and into which tubes, as shown in Fig. 4, are placed. The coal is pulverized in the presence of water, by the grinding action of the tubes and of the tubes on the walls of the chambers, when the mill is rotated. The mill in the Washington laboratories was composed of seven of these cylinders, and a large

number of tubes, as shown: the tubes in the central cylinder or chamber being larger than the tubes in the other six chambers. Coal and water are fed into these chambers through a curved pipe rotating with the mill, and which dips into a chamber filled with crushed coal and water at every revolution. A section of the feeding device is shown in Fig. 5. The pulverized coal is discharged through the opposite end.

It would appear that the loss in iron due to the abrasion of these pipes on each other, and on the walls of the containing chambers, would be considerable; but the writer was informed that this appeared to be comparatively small, and that ordinary iron pipes proved to be more economical in this respect than pipes made of a specially hard steel. The agitator or amalgamator, as it is called, is shown in Figures 6 and 7. Fig. 6 represents a vertical section through the centre, and shows the arrangement of the paddles, the oil feeds, admission for the pulverized coal and water, and also the discharge. Fig. 7 is a top view of the amalgamator. This apparatus does not require detailed description inasmuch as the drawings are self explanatory.

Finished Product.—When the separation is complete, the mixture consists of an agglomeration of the oil and carbon with a small amount of ash, and the water in which the larger portion of the mineral is contained. For making a separation, gasoline, kerosene, light oils, or fuel oils may be used. The oil commonly used, however, is "navy fuel oil," and the amount required, as stated before, varies with the coal treated, and is from 40 to 45 per cent by weight of the fuel treated.

The Trent Process Corporation advocate the burning of this amalgam directly under steam boilers, and at the time of the writer's visit they were experimenting with different methods for conveying the fuel from the plant to boilers which were situated in the boiler house of the Bureau of Standards, and also with various hearths on which the amalgam could be burned successfully. It must be understood, however, that while this amalgam possesses some of the properties of what is known as a colloidal fuel, it is, strictly speaking, not a colloid, since in the latter the carbon matter is held in suspension in the oil, and the mixture of oil and carbon matter known as colloidal fuel can be transmitted through pipes and burned in oil burners in the same manner as crude oil or fuel oil; while the Trent amalgam, when it reaches the furnace hearth, must be treated more as a solid, and must be burned in somewhat the same manner, as a solid fuel.

Recovery of Oil and Briquetting of Purified Coal.—The Trent Process Corporation have also devised a method for retorting this amalgam in order to recover the oils and the volatile matter from the coal. If the coal is a bituminous coal, it leaves a carbonized residue in the retort suitable for briquetting. If the coal pulverized happens to be a coking coal this method for extracting the added oil and the volatile content of the fuel might be successfully employed, since the finely divided fuel, which before treatment had to be ground to 200 mesh, would fuse together. On the other hand, if the fuel treated is a non-coking bituminous coal, the size of the individual particles making up the coal would be, after the completion of the retorting process, much smaller than 200 mesh, and a fuel possessing this degree of fineness cannot be profitably mixed with a binder, and briquetted, on account of the excessive quantity of binder which would be required to cover the enormous surface which the finely divided coal would present.

The efficiency of the ash separation depends very largely on the fineness to which the coal is pulverized, and it will, therefore, be readily seen that, if coarser grinding is resorted to, the ash reduction will be notably less.

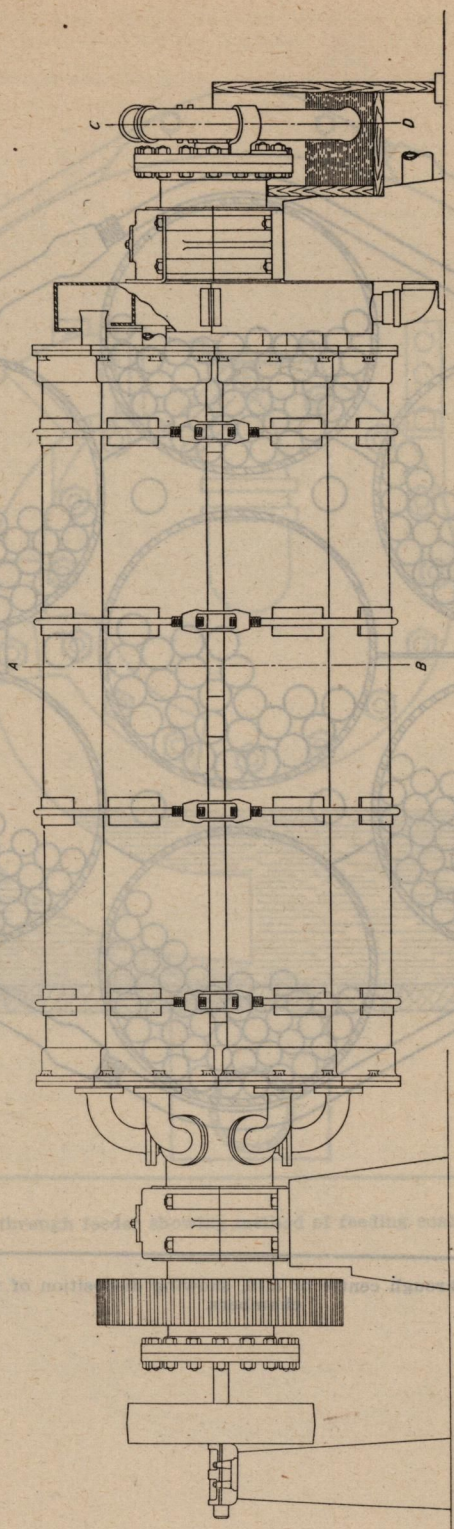

Fig. 3. Longitudinal elevation of Pulverizer.

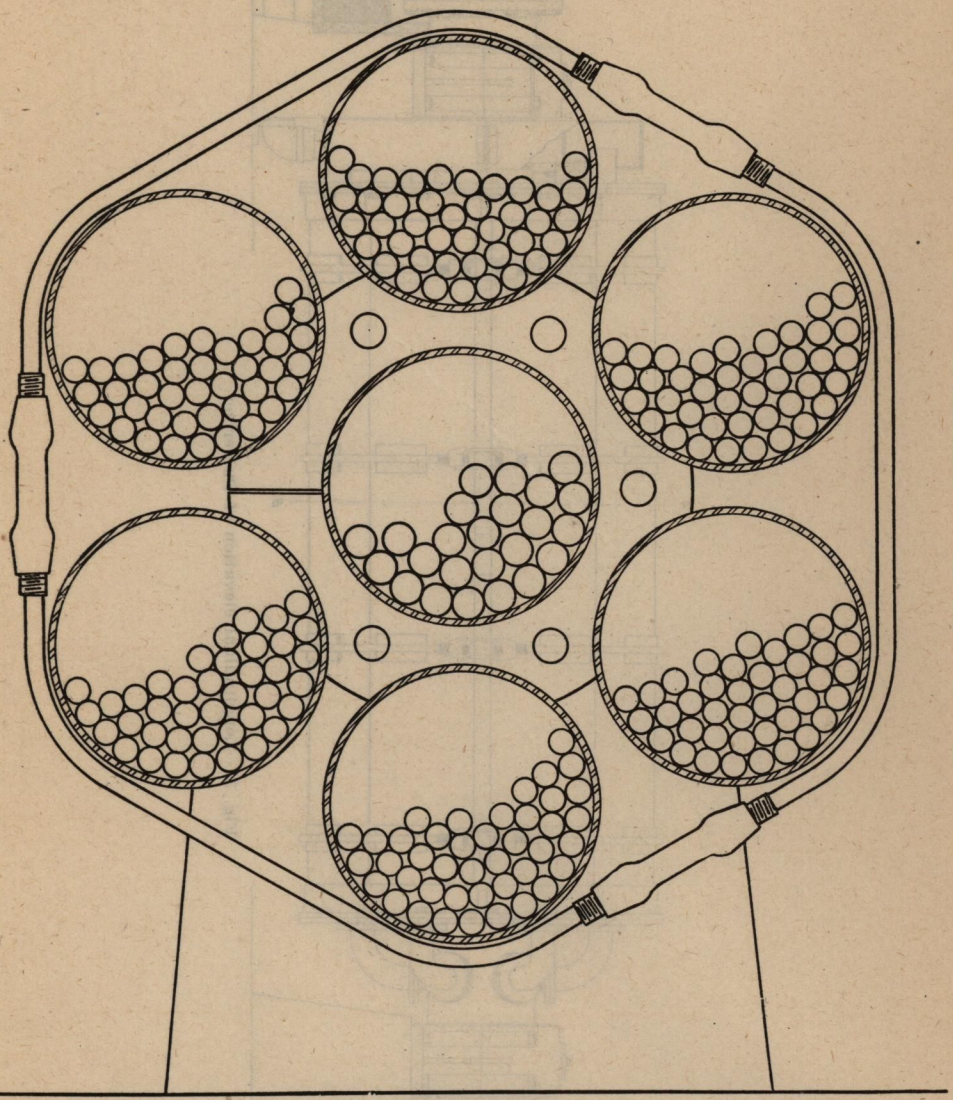

Fig. 4. Section A-B through centre of mill, showing disposition of tubes in cylindrical chambers.

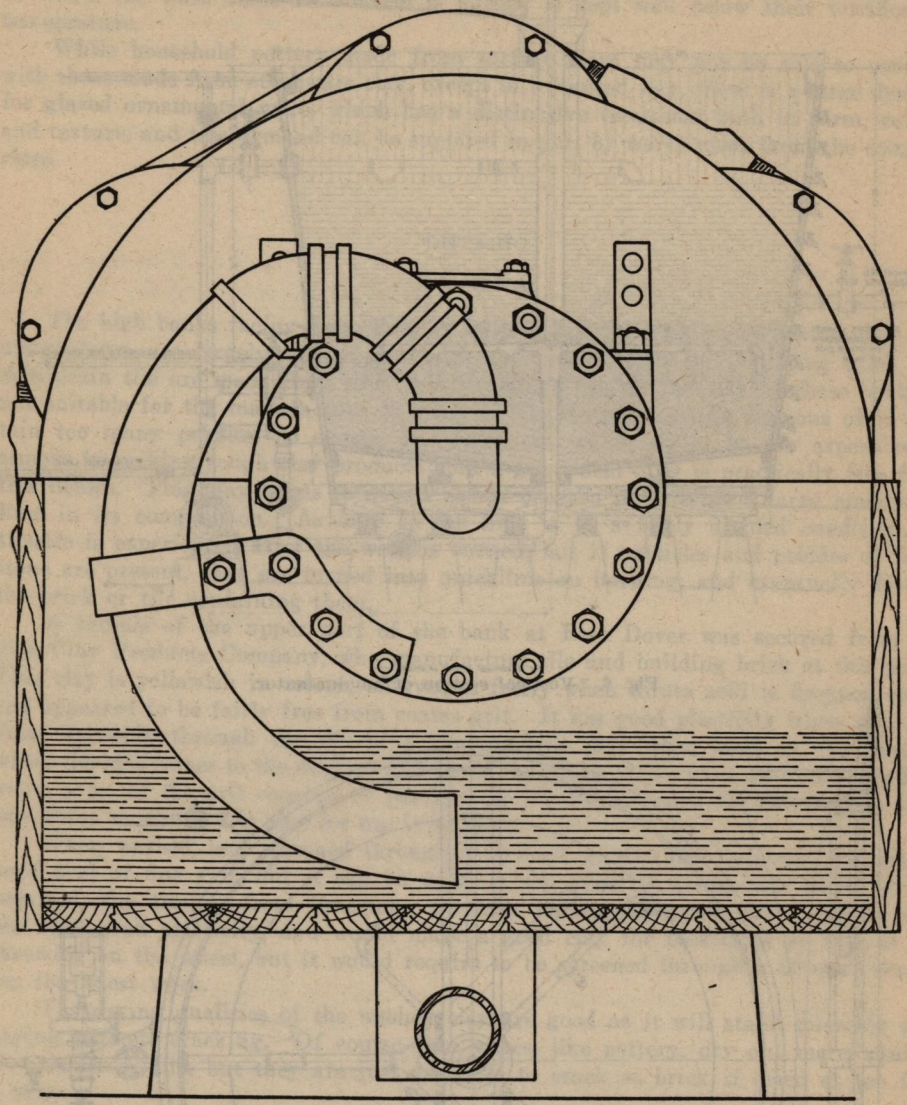

Fig. 5. Section C-D through feeder showing method of feeding coal to pulverizing chambers.

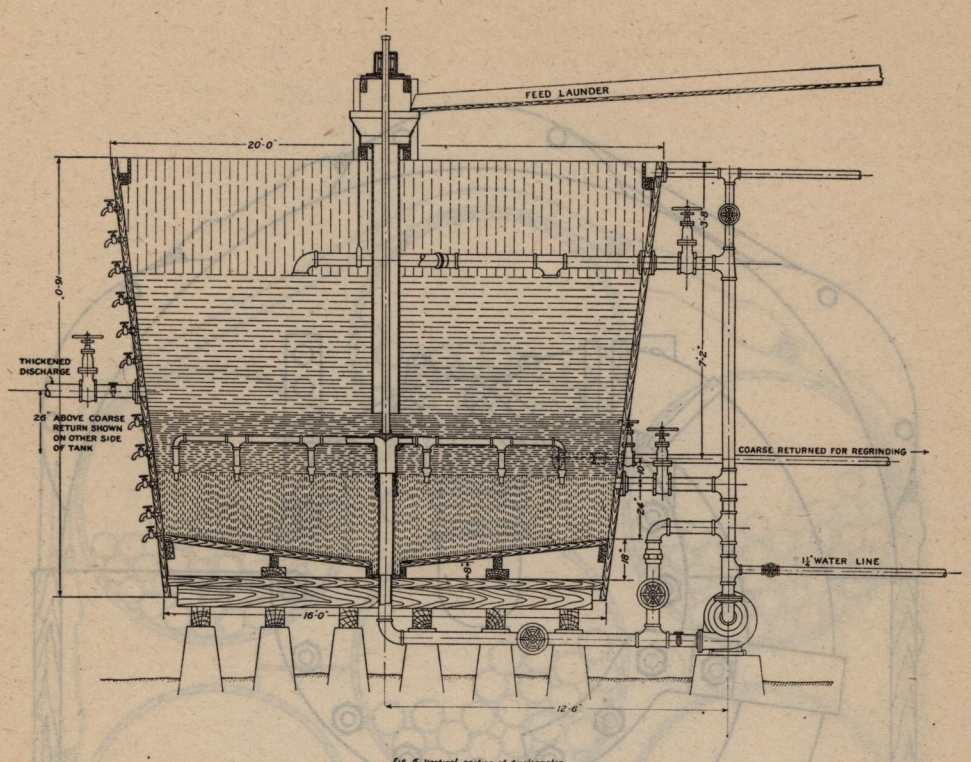

Fig 6 Vertical section of Amalgamator

Fig. 6. Vertical section of amalgamator.

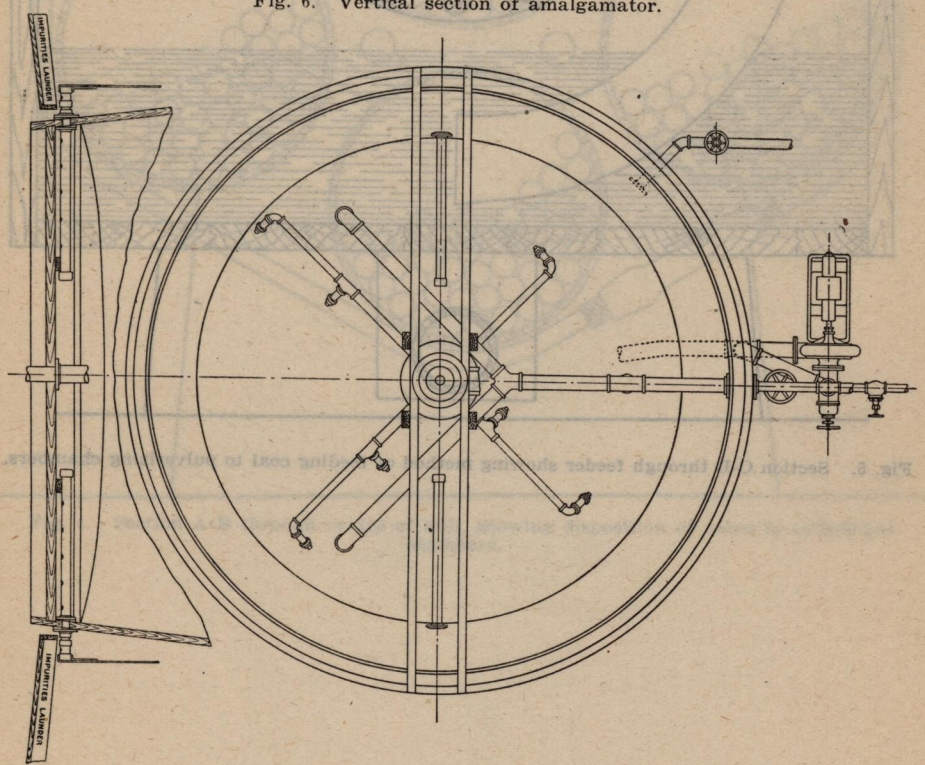

Fig. 7. Top view of amalgamator.

SAMPLES OF COAL SENT FOR PURIFICATION TO THE TRENT PROCESS CORPORATION LABORATORIES, WASHINGTON, D.C., U.S.A.

The following samples of coal were obtained through the courtesy of the Provincial Mineralogist, British Columbia, and the Chief Inspector of Mines of Alberta and Nova Scotia:—

Nova Scotia—

1—Greenwood Coal Co., No. 2, Bal. No. 2, East Landing, 6 pounds.
2—Greenwood Coal Co., No. 1, West, 6 pounds.
3—Greenwood Coal Co., No. 3, left of slope, east side, 2 pounds.
4—Greenwood Coal Co., No. 1, Bal. No. 2, West, 2 pounds.
5—Greenwood Coal Co., No. 3, left, west side of slope, 2 pounds.
6—Greenwood Coal Co., Tar King coal, 2 pounds.

Alberta—

1—Maple Leaf Mine No. 133, operated by the Bellevue Collieries, Bellevue, Alberta, 4 pounds.

British Columbia—

1—No. 5 mine, lump coal, Canadian Collieries (Dunsmuir), Union Bay, B.C.

Saskatchewan—

1—Sample of lignite sent from the Fuel Testing Station, Ottawa, which was obtained from the Shand mine, Southern Saskatchewan.

RESULTS OF TESTS

Lignite: from Shand Mine, Southern Saskatchewan

Description	Moisture	Volatile	Fixed carbon	Ash	Original Ash removed	Original Carbon recovered
	%	%	%	%	%	%
As received	16·45	29·92	38·72	14·91	.....	.....
Moisture free	.....	35·52	45·92	18·56	.....	.....
Navy fuel amalgam	.....	.....	.....	4·95	.....	.....
Dry purified coal	.....	.....	.....	7·47	64	.....
Coke or carbon from original	.....	.....	71·18	28·82	.....	.....
" " purified	.....	.....	76·31	23·69	.....	.....

Per cent of navy fuel oil required (by weight) 44%. Specific gravity ·86.

Coal: from Greenwood Coal Co., No. 2, Bal. No. 2, East Landing

As received	3·14	22·37	59·00	15·49	.....	.....
Moisture free	.....	23·41	60·41	16·18	.....	.....
Navy fuel amalgam	.....	.....	.....	3·56	.....	98
Dry purified coal	.....	.....	.....	5·34	72	98
Coke or carbon from original	.....	.....	78·88	21·12	.....	98
" " purified	.....	.....	89·55	10·45	58	98
Residue from wash water	.....	.....	14·92	85·08	72	98

Per cent of navy fuel oil required (by weight) 43%. Specific gravity ·86.

Coal: from Greenwood Coal Co., No. 1, west

Description	% Moisture	% Volatile	% Fixed carbon	% Ash	% Original Ash removed	% Original Carbon recovered
As received	2·93	22·57	54·51	19·99	.....	.....
Moisture free	.....	23·42	56·05	20·53	.....	 98
Navy fuel amalgam	.....	.....	.....	6·00	.....	98
Dry purified coal	.....	.....	.....	9·00	62	98
Coke or carbon from original	.....	.....	73·23	26·77	.....	98
" " purified	.....	.....	84·78	15·22	53	98
Residue from wash water	.....	.....	19·00	81·00	62	98

Per cent of navy fuel oil required (by weight) 42%. Specific gravity ·86.

Coal: from Greenwood Coal Co., No. 3, left of slope, east side

As received	2·70	23·30	57·08	16·92	.....	.....
Moisture free	.....	24·02	58·67	17·31	.....	.....
Navy fuel amalgam	.....	.....	.....	4·50	.....	99
Dry purified coal	.....	.....	.....	6·75	79	99
Coke or carbon from original	.....	.....	77·24	22·76	.....	99
" " purified	.....	.....	88·38	11·62	59	99
Residue from wash water	.....	.....	12·05	87·95	79	99

Per cent of navy fuel oil required (by weight) 43%. Specific gravity ·86.

Coal: from Greenwood Coal Co., No. 1, Bal. No. 2, west

As received	3·38	21·41	59·51	15·70	.....	.....
Moisture free	.....	22·32	61·47	16·21	.....	.....
Navy fuel amalgam	.....	.....	.....	4·88	.....	.....
Dry purified coal	.....	.....	.....	7·32	60	98·5
Coke or carbon from original	.....	.....	79·12	20·88	.....	.....
" " purified	.....	.....	87·58	12·42	48	.....
Residue from wash water	.....	.....	17·82	82·18	60	98·5

Per cent of navy fuel oil required (by weight) 43%. Specific gravity ·86.

Coal: from Greenwood Coal Co., No. 3, left, west side of slope

As received	2·35	22·61	58·97	16·07	.....	.....
Moisture free	.....	23·22	60·29	16·49	.....	.....
Navy fuel amalgam	.....	.....	.....	5·81	.....	.....
Dry purified coal	.....	.....	.....	8·71	57	98·8
Coke or carbon from original	.....	.....	78·70	21·30	.....	.....
" " purified	.....	.....	86·24	13·76	38	.....
Residue from wash water	.....	.....	15·05	84·95	57	98·8

Per cent of navy fuel oil required (by weight) 43%. Specific gravity ·86.

Tar King Coal: from Greenwood Coal Co.

As received	2·75	20·93	53·36	22·96	.....	.....
Moisture free	.....	21·42	54·94	23·64	.....	.....
Navy fuel amalgam	.....	.....	.....	6·77	.....	98
Dry purified coal	.....	.....	.....	10·15	65	98
Coke or carbon from original	.....	.....	69·89	30·11	.....	98
" " purified	.....	.....	84·00	16·00	44	98
Residue from wash water	.....	.....	13·30	86·70	65	98

Per cent of navy fuel oil required (by weight) 40%. Specific gravity ·86.

Coal: from Blairmore, Alberta, Canada

Description	% Moisture	% Volatile	% Fixed carbon	% Ash	% Original Ash removed	% Original Carbon recovered
As received	·50	20·44	60·05	19·01	.....	.....
Moisture free	.....	20·54	60·35	19·11	.....	.....
Navy fuel amalgam	.....	.....	.....	7·50	.....	.....
Dry purified coal	.....	.....	.....	11·25	47	99
Coke or carbon from original	.....	.....	75·93	24·07	.....	.....
" " purified	.....	.....	82·57	17·43	41	.....
Residue from wash water	.....	.....	9·71	90·29	47	99

Per cent of navy fuel oil required (by weight) 42%. Specific gravity ·86.

No. 5 Mine lump coal, from Canadian Collieries Co. (Dunsmuir)

As received	·65	33·89	52·61	12·85	.....	.....
Moisture free	.....	34·11	52·96	12·93	.....	.....
Navy fuel amalgam	.....	.....	.....	4·00	.....	.....
Dry purified coal	.....	.....	.....	6·00	57	99·5
Coke or carbon from original	.....	.....	80·46	19·54	.....	.....
" " purified	.....	.....	87·50	12·50	42	.....
Residue from wash water	.....	.....	7·19	92·81	57	99·5

Per cent of navy fuel oil required (by weight) 47%. Specific gravity ·86.

Comparative Test of Canadian and North Dakota Lignites

Description	Canadian Lignite from Shand Mine	North Dakota Lignite
	Before Treatment	Before Treatment
Moisture	16·45	13·85
Volatile	29·92	40·23
Fixed carbon in coal as received	38·72	32·55
Fixed carbon in coke as received	71·18	70·25
Ash in coal as received	14·91	13·37
Ash in coke	28·82	29·75

Description	After Treatment	After Treatment
Ash in amalgam	4·95	2·52
Ash in dry purified coal	7·47	6·53
Ash in coke	23·69	15·18
Volatile in dry purified coal	36·55	52·54
Fixed carbon in dry purified coal	71·18	40·93
In coke	76·31	84·82

It will be noted that in all cases a very notable reduction in ash is obtained, and that the oil required of specific gravity 0·86, varies from 40 per cent to 47 per cent in the case of the coal received from the Canadian bituminous collieries; and 44 per cent in the case of the Shand lignite. The original ash removed in the Shand lignite is fairly high, namely, 64 per cent. The results of tests conducted at the Trent Process

Corporation laboratories on Shand lignite and North Dakota lignite are also given, together with the time required for treatment. It will be seen that the analyses of the two lignites are very similar, and that a much better ash separation was obtained with the North Dakota lignite, but the difference in time required for agglomeration, namely, 25 minutes for the Shand lignite, is extremely marked. The engineers of the Trent Process Corporation stated, in a letter to me, that they did not get the action so rapidly on the North Dakota lignite owing to a flocculent material that is lighter than water, and remains in suspension. When this material was removed before treatment the time for agglomeration was reduced from 9 hours to 45 minutes, and the material removed analysed 70 per cent non-carbonaceous matter. It is also the belief of the chief engineer to the Corporation, that the difficulty in agglomerating the North Dakota lignite is largely due to its high oxygen content; but no oxygen determination was made on the two samples of coal cited.

CERAMIC DIVISION

Joseph Keele

Chief of Division

OUTLINE OF WORK DONE

The field and laboratory work of the Ceramic Division for the past season consisted in the investigation of raw materials used in the ceramic industries. These include clays, shales, feldspar, quartz, limestone, talc, bauxite, magnesite, etc.

A large number of samples of clays and shales were tested for people in various parts of the Dominion; but as the most of these samples were not very intelligently collected, and the locality from which they came was not very clearly indicated, the results of the tests are not recorded.

In view of the fact that most people do not know how to examine and sample a deposit of clay or shale, it has been deemed advisable to devote a part of this summary report to the giving of definite instructions to unskilled prospectors and others relative to the proper way to select samples from promising deposits. See pp. 67-70.

The proper sampling of deposits, especially those liable to variation at depth, or those containing impurities, is very important.

Certain clays which might be utilized for the manufacture of pottery were tested in the laboratory, and the results given in the following pages. These clays are of low grade, but when prepared are quite plastic and smooth, so that they may be used for the manufacture of ornamental pottery, or for instruction in modelling in schools where training in manual arts is given.

Refractory clays are of rare occurrence in Canada, and no new localities for them were recorded during the past season.

The field work done in 1920 consisted of a continuation of the survey of available structural materials along the St. Lawrence river; the principal part of the time being spent in Soulanges, Vaudreuil, and Beauharnois counties, Quebec, and in Glengarry county, Ontario. Mr. L. H. Cole was also engaged on this work, and a joint report on the resources of the region has been completed.

A short journey was made by the writer in August to the Missinaibi river in northern Ontario, in order to examine certain deposits of high grade sands and clays.

Owing to the difficulty of obtaining qualified assistants, the work accomplished by the Ceramic Division both in the field and laboratory was necessarily limited.

TESTING OF BRICK AND FIRECLAYS FROM THE VARIOUS PROVINCES

BRITISH COLUMBIA

VANCOUVER

Some interesting clays occur on the south side of Burrard Inlet, at the east end of Queen street, and two miles west of Barnet. Samples of these were collected by Mr. W. A. Johnston of the Geological Survey, and sent to the Mines Branch to be tested.

These clays are seen outcropping about 20 feet above the level of the railway tracks at this point. A bed of white clay overlies grey shale, and some inferior lignite is associated with the clays.

The white clay is rather crumbly, and short in texture, when wet; it has a high shrinkage, and cracks in drying.

It burns to a buff coloured hard body, but its fire shrinkage is excessive. This clay fuses to a slag at cone 9 (1310 degrees C.), so that it cannot be considered refractory. Owing to its defective drying qualities and high shrinkage, this clay is of little value for the manufacture of burned clay products.

The grey shale when ground and mixed with water has good plasticity and working qualities, but it cracks rather badly in drying. Some test pieces were made up by the dry press process. One of these fired to cone 9 showed no sign of fusion or softening. It was of a dark buff colour, and the body was hard and dense.

This shale does not begin to soften until a temperature of 1450 degrees C. is reached, so that it has semi-refractory properties. It does not shrink so much as the white clay. A mixture of the two clays was made up in dry press test pieces, and these burned to a fine buff colour and hard body without cracking, but the shrinkage was too great.

It seems difficult to suggest any use for these clays; but a mixture of them might be used for facing brick in building. The full size dry-press brick might crack, although the small test pieces made up by the dry-press process did not.

Spence Bridge

Brick Clays.—A bank of stratified clay from 50 to 100 feet high occurs in a cutting on the Canadian National railway, on the north side of Thompson river, about half-a-mile west of the station at Spence Bridge. A sample of this clay was collected for testing by Mr. H. S. Spence of the Mines Branch.

It is a light-grey, calcareous silty clay, fairly smooth and plastic when wet, and has good working qualities. It flows smoothly through a round tile die, but while it is all right for the smaller size of tile, the clay may not have tensile strength enough in the wet state to hold its shape when made up into the large sizes.

This clay has fairly good drying qualities, and the shrinkage in drying is about 7 per cent.

It burns to a light red, porous, but strong body, and would make a very fair grade of common building brick.

The clay would not be suitable for the manufacture of vitrified wares, as its softening point is too low.

Okanagan Landing

A sample of clay from this locality was collected by Mr. R. W. Thomson, resident engineer, Kamloops district, and sent to the Mines Branch for testing.

This is a light grey, soft, rather highly calcareous silt. It does not contain much real clay substance, consequently its plasticity is low. This material is so flabby in the wet state that it was difficult to mould it into shape.

It burns to a pale red, porous, and rather weak body. Its only use would be for the manufacture of soft-mud brick for filling or backing walls.

This clay is not so plastic as that from Spence Bridge, and while the clay from Spence Bridge might be used for field drain tile, it would seem impossible to use the Okanagan clay for this purpose.

NORTHERN ONTARIO

Clays and sands on Missinaibi river

Brick Clays.—The greater part of the region along the line of the National Transcontinental railway is underlain by boulder clay; but at certain points stratified clays, almost free from stones, are to be found, and these may be utilized for the manufacture of brick and tile.

The railway station at the crossing of the Missinaibi river is named Mattice. About half-a-mile east of the station, a small stream has cut down through a deposit of stratified clay, as far as the underlying stony clay, a depth of 8 feet. This deposit consists of alternating layers of ash coloured silt and brown plastic clay. In the middle and lower part of the section there are occasional small pockets of coarse gritty rock particles, and individual pebbles are sparingly scattered through the deposit. An average sample of this deposit was collected for testing. The clay was found to have

good plasticity and working qualities, so that it could be used for the manufacture of drain tile as well as brick. The drying qualities were not tested, but similar clays in this region were found to crack, if subjected to fast drying. This clay burns to a buff or light cream colour, with a total shrinkage of 6 per cent and forms a hard brick when fired to about 1900 degrees Fahr.

There are a few particles of limestone in this clay, and these are detrimental to the burned brick, owing to their tendency to swell on taking up moisture from the air and spall off portions of the brick or tile.

The upper part of the deposit appears to be more free from pebbles than the lower, so that a good deal of the trouble from limestone could be avoided by working only the upper 4 feet.

The upper part of the deposit is weathered, and the lime leached out for a depth of about 18 inches below the surface. This part is very stiff and plastic, burning to a dense hard red coloured brick.

A more extensive deposit of the stratified clay occurs on the west bank of the Missinaibi river, on Mr. John Christianson's ranch, which is similar in character to that just described.

Fireclays.—A fairly large exposure of fireclay and white sand occurs on the east bank of the Missinaibi, about 4 miles above the mouth of the Wabiskagami river, and 45 miles north of Mattice station.

These materials are of Cretaceous age, and underlie the glacial drift; they outcrop for about half a mile along the bank, and at one place are visible to a height of 30 feet above the low water stage of the river.

The clay is of various colours, white, pink, and yellow, but masses of mottled pink and white clay prevail. The greater part of the deposit, however, is quartz sand, generally white in colour, but stained in places to a yellowish or pink colour. The whole deposit is overlain by grey stony glacial clay, and some of this clay is pressed into and mixed with the Cretaceous clay for a depth of several feet. Two small streams which cut through the overlying glacial drift exposes the fireclay beds, and form convenient places to examine the deposit.

As the mottled pink and white variety formed the bulk of the mass of clay exposed, a sample of it was collected for testing purposes.

This clay is very plastic, with good working and drying qualities.

When burned to cone 9 (1310 deg. C.), it has a hard light red body, with an absorption of 13 per cent, and a total shrinkage of 10 per cent. It begins to soften at cone 27 (1670 deg. C.), so that it is a No. 3 fireclay, which would make a good commercial grade of fire brick.

This material could also be used for the manufacture of stoneware goods, but as it contains a quantity of quartz particles, it would have to be washed and screened in order to render it smooth enough for this purpose.

The chemical composition of the mottled fireclay as determined by Mr. A. Sadler of the Mines Branch is as follows:—

Silica	(SiO_2)	55·17
Alumina	(Al_2O_3)	28·06
Iron	(Fe_2O_3)	5·36
Lime	(CaO)	0·23
Magnesia	(MgO)	0·16
Potash	(K_2O)	0·26
Soda	(Na_2O)	0·03
Water		9·13

A large portion of the deposit on the Missinaibi river consists of coarse grained quartz sand. The sand grains are coated with white, and in some places pink and yellowish clay. A sample of sand collected from this deposit was washed and yielded only 4 per cent of the white clay, but some portions of the sand contain a larger

quantity of clay. The texture of the washed sand is shown by the following screen analysis:—

Retained on	10-mesh	screen	8·27 per cent
	20 "	"	19·47 " "
	35 "	"	38·04 " "
	100 "	"	32·44 " "
	200 "	"	1·33 " "
through	200 "	"	0·10 " "

The chemical composition of the washed sand is as follows:—

Silica	(SiO_2)	97·72 per cent
Alumina	(Al_2O_3)	0·42 " "
Iron	(Fe_2O_3)	0·32 " "
Lime	(CaO)	0·28 " "
Magnesia	(MgO)	0·21 " "
Loss on ignition		0·12 " "

The grain size or texture of the washed sand is suitable for glass making purposes, but the iron content is a trifle too high for white glass, but would answer for coarse glass products such as bottles, where a water white colour was not essential.

A small portion of the clay and sand along the immediate bank of the river could be obtained without removing much overburden, but farther away from the bank the topping of glacial dirt increases in thickness, and consequently becomes more difficult to remove.

Another deposit of this description occurs on the bank of the Wabiskagami river about 2 miles west of the Missinaibi deposit. The white sands and clays are exposed for a height of 10 feet above low water level, and are overlain by a great thickness of glacial debris. These two occurrences may be a continuous deposit underneath the glacial drift, but it was difficult to prove it by boring with an auger, owing to the presence of numerous stones in the overburden.

QUEBEC

Little Métis. Matane Co.

A large outcrop of grey shale is exposed in the Intercolonial railway cutting between Little Métis and Kemp stations, and an average sample was collected for testing purposes.

This shale, Sample No. 731, was prepared for testing by grinding, so that it would pass a 12-mesh screen. The ground shale was only feebly plastic, and was difficult to mould into shape. It can be dried very quickly, and has very little drying shrinkage.

If this shale was mixed with some plastic surface clay, it could be used for the manufacture of wire-cut building brick, or this mixture would also be suitable for dry-pressed brick.

Equal parts of clay and shale would give a good red brick by either process, similar to those made at Laprairie.

This shale is not suited to the manufacture of vitrified wares, such as paving blocks, as it will not stand up under the temperature necessary for vitrification.

St. Octave. Matane Co.

Two samples of shale from this vicinity were submitted by Mr. Arthur L. Landry of St. Octave.

One sample of shale was red and the other grey, but both appear to belong to the same rock formation. These shales, when ground, and mixed with water, developed a low plasticity sufficient to allow of them being forced through the die of a brick machine.

They stand fast drying without cracking, and the shrinkage in drying is low.

The red shale burns to a dark or brownish-red colour, and the grey shale to a light brilliant red. The bricks made from these shales are hard and dense when burned to a temperature of 2,000 degrees Fahr. (Cone 03), and are not quite vitrified. These shales will stand a higher temperature without softening, so that they can safely be used for the manufacture of paving blocks or other vitrified clay products.

Both shales begin to soften at Cone 7 (2318° F.), and are not quite fused at Cone 9 (2390° F.), so that they are true vitrifying shales, a type comparatively rare in this region.

These shales could be used for making a fine grade of rough texture face brick for buildings, but for hollow ware or sewer pipe they would require the addition of about 25 per cent of a good plastic clay to enable them to flow through the hollow dies used in shaping these wares.

Petite Romaine, Iberville tp. Chicoutimi Co.

On the shore of the St. Lawrence river, at this point, there is a thick deposit of light grey clay underlying from 10 to 15 feet of sand, peat, and yellow ochre. The clay is very silty in character and low in plasticity. It burns to a light red colour, and very porous body. This is a low grade clay, but it might be used for the manufacture of a common building brick, by the soft-mud process, if nothing better was available in the district.

Vaudreuil

About two miles east of the village of Vaudreuil, the Canadian Pacific railway line cuts through a high bank of clay.

This locality should be a favourable point for the manufacture of building brick and field drain tile. The clay is well situated for excavating, and is covered with about two feet of yellow sand, which could be used for mixing with the clay or as a brick moulding sand. A small creek flows along the bottom of the bank, from which a permanent supply of water could be obtained. The clay along the bank of the creek is a yellow, sandy variety, with a low shrinkage, and burning to a fine, hard, red coloured body, and is better for brick-making than the clay in the high bank. The clay in the high bank could be used for both drain tile and brick when mixed with the top sand.

There is an abundance of clay in the counties of Vaudreuil and Soulanges, but as it mostly lies in flat plains, it would be difficult to excavate it on account of surface water coming into the pits, but the high bank noted above would not be open to this objection.

A supply of wood for burning the clay wares could be procured during the winter months from the slopes of Rigaud mountain about eight miles distant.

NEW BRUNSWICK

Hebert—Kent Co.

A thin coal seam occurs at this locality, but no mining operations beyond prospecting have been undertaken. Two samples of clay lying above the coal seam were collected and tested. Lab. No. 737, is a hard, grey, non-calcareous shale, overlying the coal seam. This shale has good plasticity when ground and mixed with water, and works well through both a solid and hollow die. The shrinkage on drying is only 3 per cent. The following results were obtained on burned test pieces:—

	% fire shrinkage	% absorption	Colour
Cone 010	0	12	light red
06	0	11	red
03	3	5	dark red
5	fused		

This material would be suitable for the manufacture of either wire-cut or dry-pressed building brick. It would also be a good material to use for the manufacture of hollow building blocks, as the shrinkages both on drying and burning are low, and the burned body is hard and strong. A better hollow ware would probably be obtained by mixing this shale with the upper clay, No. 736. A mixture of equal parts of these clays would produce a good variety of clay products for building purposes.

The material is not a fireclay, neither is it semi-refractory, Lab. No. 736. This is a soft, yellowish clay, which lies above No. 737. It is very plastic when mixed with water, and makes a smooth bar when pressed through a die. The shrinkage of 9 per cent which it undergoes in drying is rather great.

The following results were obtained on burned test pieces:—

	% fire shrinkage	% absorption	Colour
Cone 010	0	16	light red
06	3	6	red
03	8	vitrified	dark red
4	fused		

This clay would be suitable for the manufacture of building brick or field drain tile. A mixture of this clay with the lower shale No. 737 is recommended for a larger range of products.

Claire Fontaine—Kent County

A purple coloured, weathered shale outcrops on a bench of Little Black river, about three-fourths of a mile above the shore road. This clay is known as "blue paint" in the vicinity.

The sample collected, Lab. No. 739, consisted of hard and soft lumps of purplish coloured clay, which is very plastic when wet, but rather stiff. It is smooth and free from coarse grit, and has good working and drying qualities.

It burns to a light red, rather porous body, at the lower temperatures, but becomes denser and darker in colour when subjected to higher heats, and finally vitrifies at cone 03. This clay is suitable for the manufacture of wire-cut building brick, or field drain tile, the only objection to it being the fact that the shrinkages are rather great. As the sample was taken from the softened outcrops it is possible that different results would be obtained from the hard unweathered shale beneath the surface. This material is not a fireclay, but on the contrary is rather easily fusible.

NOVA SCOTIA

There is a growing demand for a more permanent building material than wood in the Maritime Provinces; also for one that will resist the spread of fire in the growing towns and cities. Burned clay products fill these requirements more effectually than any other class of structural material. Many owners of existing brick plants, that use only the surface clays for common brick, are desirous of improving their products, and are looking for shale deposits to use either alone or in a mixture with the surface clay.

Experiments were carried out in the Mines Branch laboratory for Mr. L. H. Shaw at Avonport, on a shale deposit which occurs near his plant. A mixture of equal parts clay and shale were found to be suitable for hollow ware or rough-faced brick, and arrangements are now being made to produce these wares.

Shale deposits in other parts of the province, not previously reported on, were also examined, and the results of the tests are given in the following pages. The red shale on the roadside near the village of Shubenacadie is worth attention, as a mixture of this and the brick clay, at that point, would give good results in this connexion.

INVERNESS, C.B.

Red shale outcrops on the main highway near Broad Cove chapel, about four miles north of Inverness. A sample, Lab. No. 738, was collected at this point for testing.

This material, when ground to pass a 12-mesh screen, does not entirely slake when mixed with water, but remains gritty in the wet state, consequently its plasticity is low.

It can be dried rapidly without cracking, and the shrinkage in drying is small.

This shale burns to a hard, dense body of fine red colour, and would make excellent building brick, either by the wire-cut or dry-pressed process.

The temperature at which this shale softens is comparatively low, so that it is doubtful if it could be used for the manufacture of paving brick or other vitrified products.

TRURO

Greenish-grey, hard shale outcrops in a bank on the road near North river, about four miles north of Truro, and the same shale forms the east bank of the river in this vicinity. A sample of this shale was collected for testing by Mr. H. Gauthier of the Mines Branch.

The shale, when ground to pass a 16-mesh screen, and mixed with water, develops enough plasticity to enable it to be run through a brick die. Its plasticity, however, is low, and the shale would have to be mixed with some plastic clay before it could be used for making hollow ware.

It burns to a light red, rather porous body, at the lower temperatures, but becomes darker and denser with longer burning.

This shale is not suitable for the manufacture of vitrified wares, as its softening point is too low.

Some thin coal seams have been found at East Mountain in Colchester county, eight miles east of Truro.

A small sample of grey clay shale associated with the coal was sent by Mr. O. R. Harlow, of Truro, to the laboratory in the hope that it might be a fireclay. This clay does not stand a high enough temperature to be classed even as semi-refractory, as it fuses to a slag at the softening point of pyrometric cone 7 (2318 degrees F.), whereas a fireclay is required to stand at least 3000 degrees before softening.

SHUBENACADIE

Outcrops of gritty red shale occur along the Halifax-Truro highway, near Dewis Siding, just south of the village of Shubenacadie, a sample of which was collected for testing by Mr. Gauthier of the Mines Branch.

This shale, when ground to pass a 16-mesh screen, and mixed with water, develops enough plasticity so that it can be forced into shape through a brick die.

It burns to a strong body of good red colour.

This shale can be used alone either for making wire-cut brick by the plastic process, or for facing brick by the semi-dry pressed process. It would improve the working qualities to add some of the plastic surface clay from the same locality. A mixture of equal parts ground shale and clay would make excellent hollow building blocks, and rough-faced building brick of fine red colours.

This shale is not suitable for the manufacture of vitrified wares. Grey plastic shales occur two miles west of Shubenacadie, on the property of Mr. John McDonald. The shale weathers easily at the surface into a yellowish plastic clay. The thickness of the shale bed is unknown, but it is at least four feet thick when exposed in the field near Mr. McDonald's house. The same shale is also seen on Ryan's brook in this neighbourhood.

This shale is a good deal more plastic than the red shale on the roadside, and does not need the addition of surface clay to make it workable.

It burns to a good red colour and fairly dense body, and could be used either for hollow blocks or wire-cut brick.

There is, however, a large supply of surface clay at Shubenacadie for making brick and tile, so that it would scarcely pay to grind shales to add to it unless for making higher grade products such as rough-face brick or fire proofing, the demand for which class of product is steadily increasing.

Malagash. Cumberland County

Grey shales outcrop along the sea shore just north of the salt mines at Malagash. A sample collected at this point by Mr. L. H. Cole of the Mines Branch was tested in the laboratory.

This shale, when ground to pass a 12-mesh screen and mixed with water, developed a fair plasticity, so that it could be used for making wire-cut brick or possibly for hollow blocks.

Its drying qualities are good, and the shrinkage in drying is low, being only four per cent.

This shale burns to a red colour and hard body at a temperature of 1800 degrees. It becomes dark red in colour and vitrified at 1900 degrees.

It is not a fireclay, as it softens at a temperature of 2200 degrees.

It is possible that this shale could be used for the manufacture of vitrified products, such as paving blocks and for floor tile, if ground finely. It could also be used for the manufacture of rough-faced building brick of various shades of red and brown colours.

POTTERY CLAYS

The Summary Report of the Mines Branch for 1919 contained a chapter on tests of pottery clays from various parts of the Dominion. A short description of how pottery of various kinds is made, and the compositions of glazes and enamels with which they are coated, is included in that report. Clays from several additional localities were procured, and tested during the past season, the results of which are given in the following pages.

Surface clays, generally of glacial origin, are the principal materials upon which work was done, as these are the only kind available over the greater part of Canada.

The higher grade of clays such as stoneware clays, fireclays, and kaolin, are comparatively scarce in this country, and are restricted to a few localities. The principal accessible source of stoneware clay is confined to certain areas of southern Saskatchewan,[1] but a small quantity is also found in Nova Scotia.

As the glacial clays will not stand a very high fire, the glaze that is applied to them must be easily fusible, otherwise the ware made from them will distort when fired for the second time after the glaze coat is applied.

Nearly all the surface, or glacial clays, contain more or less grit, and are not smooth enough to be shaped on the potter's wheel, consequently they must undergo preparation which will eliminate the coarse material. This is accomplished either by slaking the clay in water and passing it through a screen, or by drying the clay and pulverizing it, but washing and screening is the method generally employed.

Heavy household pottery, such as butter crocks, mixing bowls, and jardinieres, can be made from the washed glacial clays. The only objection to their use is that the body is porous, and when the glaze becomes accidentally chipped off, a spot which gathers dirt results. The stoneware articles are not open to this objection, as even when the glaze chips, the vitrified body beneath will not absorb water.

[1] "The Clay Resources of Southern Saskatchewan," by N. B. Davis, Mines Branch, Ottawa.

The glacial clays cannot be vitrified, because when the vitrification point of these clays is approached, softening and distortion takes place, consequently the temperature at which the ware made from them is burned is kept well below their vitrification temperature.

While household pottery made from surface clays may not be able to compete with those made from stoneware clay, except in a limited way, there is a large demand for glazed ornamental ware, which has a distinctive treatment both in form, colour, and texture, and this demand can be supplied in part by wares made from the common clays.

ONTARIO

Port Dover

The high banks facing Lake Erie at Port Dover, Port Rowan, Port Stanley, and other places, are largely composed of yellowish calcareous clay. Building brick and field drain tile are made from it at certain points, but all the clay in these banks is not suitable for the manufacture of brick or tile, because certain portions of it contain too many pebbles, or stones, or concretions which would be too expensive to remove in making rough clay products; but a great deal of it is practically free from this defect. This clay burns to a buff colour because it contains a large amount of lime in its composition. As long as the lime is in a finely divided condition, no trouble is experienced after the ware is burned, but if particles and pebbles of limestone are present, they are turned into quicklime on burning, and eventually destroy the brick or tile containing them.

A sample of the upper part of the bank at Port Dover was secured from the Erie Clay Products Company, who manufacture tile and building brick at this point. This clay is yellowish in colour, effervesces freely when dilute acid is dropped on it, and appeared to be fairly free from coarse grit. It has good plasticity when wet, and flows smoothly through the die of a tile machine, but when used on the potter's wheel the grit comes to the surface and spoils the shape of the piece of ware. Furthermore, some of the grit consists of particles of limestone, hence for two reasons it is important to screen this clay for use in pottery.

When washed, and screened through a 40-mesh screen, this clay still contains a good deal of fine grit, but it can be used on the wheel if a very fine finish is not required, the trouble from limestone particles is also removed. The washed clay has very good plasticity, and would make a good clay for modelling as well as for throwing on the wheel, but it would require to be screened through a 60-mesh screen for the finest work.

The drying qualities of the washed clay are good as it will stand tolerably fast drying without cracking. Of course thin wares, like pottery, dry out more quickly than brick or tile, but they are just as liable to crack as brick if dried at too fast a rate.

The Port Dover clay burns to a buff colour with a trace of pink when fired to the softening point of pyrometric cone 06, the pink colour being more pronounced if the firing is finished at a lower temperature. The fired body is very strong and tough, but quite porous at this temperature. If fired to a higher temperature, say cone 03, this clay is liable to soften slightly and deform, it also shrinks greatly at the higher heats, and the body becomes quite hard and of a sulphur colour.

When a clear colourless glaze is applied over the burned ware, and the pieces re-fired, they come out of the kiln a rich dark buff tone. The clear glazes, however, have a tendency to craze some time after the piece is fired, but no doubt the crazing could be stopped by altering the composition of the glaze to suit the clay.

When tin oxide is mixed with the glaze, it becomes opaque, and is called an enamel. The tin enamels gave the best results on this clay; blues and greens being

especially good. By adding iron oxide to the clear glaze, a brown colour can be obtained, which does not craze so readily.

The clay might be used for the manufacture of heavy household ware, such as mixing bowls, bean pots, and jardinieres, but the expense of preparing the clay, by washing and screening off the coarse material it contains, may be prohibitive in making goods on which there is only a small margin of profit.

Several pieces of pottery made on the wheel and glazed in different colours at the laboratory of the Mines Branch, were very attractive as flower vases, or ornamental pottery.

Brantford

Deposits of glacial clay are fairly abundant in the vicinity of Brantford. Probably the thickest and most extensive stratified stoneless clay deposit in western Ontario, except on the shores of the Great Lakes, occurs along the bank of Grand river, near Cainsville, about three miles from Brantford. The old brickyard at Mohawk Park, at the east end of Colborne street, worked a bank of stratified clay and silt, but this material would not be suitable for pottery making, as it is not plastic enough.

The old brickyard, worked by Mr. W. H. Freeborn, had a red burning clay on the surface to a depth of two or three feet, and below this is a stiff brownish laminated clay which has good plasticity and burns to a hard buff body.

A similar clay is found in the pits of the Ideal Brick and Tile Company, on Stanley street, and a sample of the clay was procured for testing purposes.

This clay contains so many gritty particles that it cannot be used for making pottery on the wheel as it comes from the pit, but must be prepared by washing and screening. It is not so coarse in texture as the Port Dover clay, so that passing through a screen of 40 meshes to the inch will eliminate enough of the grit to make a very smooth and highly plastic modelling clay. The washed clay has good tensile strength and toughness, so that it can be thrown on the wheel to make any desired shape. It would also serve as a modelling clay for school use, as built pottery forms either square or round, and tiles can be made from it.

The opaque enamels which have tin oxide in their composition seem to work well on this clay, but the clear glazes have a tendency to craze. The burned colour of the body before glazing varies from a pink to a light buff according to the heats used.

Essex County

The clay used for the manufacture of brick and tile in Essex county occurs as a thin sheet on the surface of certain areas. It is seldom more than about 2 feet thick, and in some places even less, and rarely reaches to a depth of three feet below the surface. The top clay is free from lime and of a brownish colour, the clay below this is a grey stony material which is absolutely useless for the manufacture of clay products. The top clay burns to a good strong body and a fine red colour, in fact, the burned ware has the most glorious red colour that we know of among all the red clay products in Canada.

The clay as it comes from the pits contains a good deal of coarse and fine gritty particles, which must be removed by washing and screening before it can be used for modelling, or for wheel work; furthermore, it is necessary to use a screen of 60 mesh to an inch in order to make it workable for a smooth finish. This screened clay is very plastic, and has good tensile strength, so that it can be turned into any shape on the wheel, or used for modelling. Ornamental pottery made from this clay need only be glazed on the inside, the outside can rely on the fine burned red colour without the addition of glazes, or enamels, but the whole body can be glazed if desired.

Renfrew County

There is a great quantity of stoneless plastic clay of marine origin along the Ottawa and St. Lawrence rivers. It is a dark grey sticky clay, hard to dry, and has a high shrinkage. It is an unsatisfactory material to use for pottery, although a quantity of flower pots were produced from it in a small plant, but as a general rule this clay is a failure as far as pottery is concerned. This clay burns to a red colour, but at a few points there is a bed of buff burning clay below the red. Most of the buff burning underclays are very silty and only feebly plastic, but at Renfrew the underclay has very good plasticity, and better working qualities than any of the red upper clays—which is a very unusual occurrence.

A sample of the underclay was collected from the old brickyard site in the valley of Smith's creek. This clay was formerly used in the manufacture of field drain tile, it is fairly smooth, and appears to be free from coarse grit. It cannot be used, however, direct from the bank as a wheel clay, because it contains certain layers which do not slake in water, but remain in small lumps, hence it is necessary to either pulverize the dry clay very finely, or else wash and screen the clay. The washed clay is very smooth and makes an excellent clay for modelling, hence is recommended for use in schools.

SASKATCHEWAN

Estevan

The Estevan Coal and Brick Company use two different kinds of material from their mine for brickmaking, an upper clay which burns to a buff colour, and a dark grey clay which occurs below the coal seam, for making red dry-press brick.

The dark clay under the coal cracks in drying when made up into brick shapes by the plastic process, consequently it has to be used by the dry-pressed method. The lowest part of the dark clay, however, if it is used separately, is not so liable to crack in drying, as it is not so fat and pasty when wet as the upper part.

The lowest clay, however, contains a good deal of grit, but this can be removed by washing it through a 30-mesh screen. A very fine working, smooth clay is thus obtained, which is suitable for use on the wheel. None of the smaller pieces turned on the wheel cracked in drying, but some large wide pieces, like bowls, cracked across the bottom while drying. This clay burns to a very hard, dense light red coloured body, on which the glazes, either clear or opaque, did not craze.

The top material over the coal is a yellowish calcareous clay, containing a great quantity of rock particles. When washed through a 40-mesh screen it makes a clay of good consistency and working qualities for the wheel. The drying qualities appear to be good, as none of the wheel pieces showed any indication of cracking. This clay burns to a buff colour, but the burned body shows numerous small specks of a reddish colour. Clear and opaque glazes cover well on this body without crazing.

A mixture of equal parts of the clays appears to give better results than either of them used alone, because the defects of one clay are compensated by the good qualities in the other. For example, the buff clay has too porous a burned body, but it is easy to dry. The grey clay is difficult to dry, but its burned body is very dense. Furthermore, the mixture of clays forms the best body on which to apply glazes.

The mixture of clay is recommended for use in teaching modelling in the public schools of the district.

The Estevan clays may also be used in combination with the white stoneware clays found in other parts of southern Saskatchewan, in order to produce different bodies and glaze effects at lower temperature than those which the white clay alone will produce.

CLAYWORKING INDUSTRY

Structural Materials

The clayworking industry in Canada is engaged mostly in the production of structural materials, such as brick and hollow building blocks and drain tile for agricultural purposes. These are made from the surface clays of glacial origin which are so widespread over all the country; but at a few points shales from the older rock formations are the raw materials used. Vitrified structural wares, such as sewer pipes, are made to a limited extent, but no paving brick are produced, mainly for lack of the proper kind of vitrifying shales employed in their manufacture. Four plants are engaged in the manufacture of heavy household pottery and stoneware goods such as crocks and jars. Two of these plants import their clays from the United States. White vitrified floor tile are made at one point and sanitary ware and electric porcelain at two others. All the industries making white bodies import their raw materials both from England and the United States.

The industry as a whole is on a sound economic basis as it keeps pace with the demands of the country. When the capacity for consumption in the home market increases, the industry will, no doubt, expand to meet the needs.

The following table shows the value of the principal classes of clay products manufactured in Canada for the year 1919:—

Brick	$3,154,381
Hollow blocks, or fireproofing	396,084
Sewer pipe	1,074,146
Field drain tile	616,510
Stoneware pottery	185,474

Special Clay Wares

Some of the existing plants throughout Canada, engaged in the manufacture of brick and drain tile, might take up with advantage the making of a more specialized and profitable line of wares wherever they have a suitable clay or shale. There is a large and growing demand for the ordinary red floor tile used in corridors, kitchens, hospitals, and other places, which may easily be made from some of the red brick shales by simply grinding them finely. While these shales may not be suitable for tiles for outdoor use, on account of their porosity, they will give good wear on indoor positions. Roofing tile, and tile for lining digesters in the pulp mills, are other profitable lines for the manufacturers, but the latter would have to be salt glazed.

Porous clay wares, such as iceless refrigerators and water coolers, would have a large sale if any one undertook their manufacture. Vessels of this kind owe their cooling properties to their ability to soak up a large quantity of water, and the evaporation of this water as it comes to the surface keeps the contents cool. The Medalta Pottery Company at Medicine Hat, Alberta, is the only firm in Canada which makes this class of ware. This firm makes a porous water jug especially designed for keeping water cool, for workers in the fields during the hot weather.

White Table Ware

No table ware, such as white earthenware, semi-porcelain, or china, is produced in this country, the reasons probably being due to a dearth of the proper kind of raw material used in their production, and the market not being large enough.

The commoner kinds of table ware have hitherto been made so cheaply and so well in European countries, that it was impossible for a firm in Canada to compete with them. In recent years, however, the prices for these goods have increased fourfold or even more, so that there is a much better opportunity for manufacturing in Canada, at a reasonable profit.

The manufacture of staple lines would be the safest kind of business to undertake at the start. These include: (1) plain white, or, as it is sometimes called, white granite ware; (2) gilt wares, light and heavy, these being simply decorated over the glaze with a gold line, or with a stamped device in gold, the commonest on the market being the clover leaf, but the Canadian manufacturer should stamp his ware with a gold maple leaf or a beaver; (3) ware decorated with a transfer pattern in one colour, generally called printed ware; (4) water jugs, either plain white, or decorated with gilt band, or printed decoration.

There is an enormous quantity of these goods sold in Canada, and any manufacturer producing them at say 20 per cent less than the imported wares would be assured of the greater part, if not all, of the business.

Raw Materials.—A mixture of four different kinds of raw materials is used in making the above wares, these being: china-clay, ball clay, flint, and feldspar. In addition to these, a supply of fireclay is necessary for making the saggars or containers in which the ware is burned.

The present supply of china-clay in Canada is limited to one deposit, that of the Canadian China Clay Company, of Huberdeau, Quebec. This deposit is being developed by new mining methods, and a larger output of clay is promised than was formerly available. So far, no ball clay has been discovered within reach of transport in Canada. Certain of the white sandstones in eastern Canada, when pulverized, can be used for the flint in pottery.

There is a plentiful supply of high grade feldspar for pottery bodies and glazes in eastern Canada. Any firm doing a large amount of business in white earthenware could purchase the crude feldspar and quartz from the mines, and do their own grinding.

Fuel.—As it requires six tons of coal to produce one ton of white table ware, the fuel question would have to be studied closely, and particular attention paid to design of kilns and methods of fuel saving. Putting the coal through a gas producer and using the gas for fuel in a tunnel kiln seems to be the practice that is approved by most ceramic engineers.

Location.—The location for a plant making white table ware depends on various factors. Of these the assembling of raw materials, the cheapest place to deliver coal, the transportation facilities for assembling and distribution, and the labour supply, are the principal things to be taken into consideration.

Points on the St. Lawrence river up to Montreal have the advantage of ocean freight delivery of supplies of English china-clay and ball clay without re-handling, as well as access to the Nova Scotia coal fields. Points on Lake Erie, such as Port Stanley or Port Colborne, are well situated for receiving supplies of coal and fireclay from the United States, and points on the Welland canal have similar advantages for assembling raw materials and distributing finished products.

FIELD EXAMINATION AND TESTING OF CLAYS

The testing of any clay or shale for commercial purposes begins with an examination of the deposit in the field. A clay deposit should be conveniently situated with regard to transportation, and in a body large enough to keep a plant going for a considerable time, free from harmful impurities, and be easily worked. There are many important questions to be considered, however, in the preliminary inquiry, for example:—

1. Can drainage be provided as excavation or mining proceeds since it is necessary to keep the workings dry?
2. Is the water supply for all purposes adequate, and of good quality?
3. If sand is required for mixing, or moulding, can it be obtained cheaply?

4. Consideration of the fuel supply.
5. Are conditions in the locality favourable for labour?
6. Can breakages of machinery be repaired quickly?
7. Can the kiln foundations be kept dry?
8. Would further prospecting probably reveal a more desirable deposit?

Some idea of the extent of a clay deposit may be gathered in a preliminary way from outcroppings either in ploughed fields or hillsides or ridges and along the banks of streams or dry gullies. Springs issuing from hillsides sometimes furnish a clue to the upper level of a bed of clay, as the surface water cannot seep down through it. Wells and foundations excavated for buildings are useful guides; but railway cuttings often furnish the best information, especially when they are freshly made. As soft clays in a steep bank are liable to be concealed by slide material which has washed down over them, it is often necessary to cut a deep trench up the slope from top to bottom of the deposit, before the true character of the beds is seen. Some banks contain several different grades of clay, some of which may be worthless, and so situated as to render the good clay unworkable.

In addition to the information gained from outcrops it will be necessary to make several borings in order to get at the extent of the deposit and its variations. Borings can be made quickly and cheaply in surface clay deposits, with a 2-inch auger, coupled to short lengths of pipe, and fitted to a cross head. The auger is screwed into the clay for about 6 inches, then withdrawn with a straight pull, and the clay which clings to the auger removed. As the boring proceeds, extra lengths of pipe are added. The clay stripped from the auger is laid out in the proper order, on boards or on the grass, from which small samples can be selected at any depth up to 30 feet, or more if desired.

The clay deposit may be covered with a varying thickness of either gravel or stony clay which cannot be used for any purpose. In most cases it will not pay to strip this overburden if it is very thick, but the higher grades of clay, like stoneware and fireclays, can have an overburden of one foot removed for every foot of clay obtained. If the overburden is composed of sand, much of it may be used for mixing with the clay, especially if it should be a fat clay, with high shrinkage. An otherwise useless overburden may sometimes be used for filling or levelling up ground on which it is proposed to erect the plant; or it may be removed cheaply by hydraulicing, if a sufficient head of water is available. An overburden which contains pebbles, especially pebbles of limestones, should be removed completely, and kept well back from the face of the bank which is being worked, so that there will be no danger of the pebbles rolling into the material that is being worked for the manufacture of clay products.

Shale deposits are often exposed in fairly steep banks, either in an escarpment or on stream banks, or in a railway cutting. From exposures of this kind a good idea of their probable value may often be formed. If the outcrops on the property to be examined are not exposed to any appreciable depth, it will be necessary to sink some shafts before any sampling can be done or any decision formed regarding its economic value.

Several of the soft shale deposits in the plains region of western Canada can be examined as easily as surface clays from boring with an auger; but the shales in the east are all too hard for this method of sampling.

The shale formations in eastern Canada are generally uniform in character over very large areas, but those in the west are often extremely variable, so that they require great care in sampling and examination.

Impurities in clay or shale are of two kinds, those which are visible to the naked eye, and those which are not. The field examination detects the first kind, and the laboratory tests should reveal the second kind. Pebbles are probably the most serious visible impurities in surface clays. They may occur sparsely scattered throughout the clay or they may be in the form of gravel streaks, pockets, or regular layers. If the pebbles are mostly of limestone, the deposit is practically hopeless. Some manu-

facturers in search of material will not consider a deposit if they find it contains even a few scattered pebbles. Beds of calcareous clay are found, in many instances, to contain layers of concretions, but to be otherwise free from pebbles. Concretions are hard, rounded, elongated, or fantastically shaped nodules, known as "clay dogs" by men working at the clay banks. Concretions will destroy burned brick more effectively than any other form of lime, and should be rigorously excluded from the brick mixture. This may be done if the concretions occur in layers, but if they are scattered through the mass there is no hope for the deposit. Layers or pockets of sand, if not in too large a quantity, are sometimes beneficial in a surface clay, especially if it is of a highly plastic nature. Brickmakers like a clay bank to work itself, meaning one that carries the right proportion of sand to clay, but a clay deposit that is too sandy is undesirable because the product made from it is liable to be weak and porous. Although a shale deposit may consist largely of beds of true shale, it is possible that it may also contain so many layers of sandstone or limestone as to be of doubtful economic value. If the stone bands or layers are thick enough they may be sold for building stone, if a convenient market exists for them. Ironstone concretion, and lumps of iron pyrite, are among the serious impurities in shales and clays. They sometimes occur of such large size that they may be discarded in mining. Gypsum or lime sulphate is a frequent impurity in the soft shales of western Canada. It generally occurs in small, glistening particles disseminated through the shale; or it may be in large crystals or rosettes. It generally follows in the west that clays carrying gypsum are hard to dry without cracking.

It is generally impossible to foretell much about the value of a clay or shale by simply inspecting the deposit in the field. An experienced clay worker, however, can gather some information for his guidance in the selection of material. The feel of the moistened clay when kneaded in the hands indicates its degree of plasticity and its probable working qualities. A shale may be distinguished from a slate by grinding a little with a hammer and moistening it. The moistened shale dust will have more or less plasticity; but a slate will have none. Any clay or shale that carries more than about 7 per cent of lime will probably be useless for the manufacture of vitrified wares, such as paving brick or sewer pipe. If a few drops of diluted hydrochloric acid will produce strong effervescence in a clay it may be discarded as unsuited for this purpose.

Many clays will crack in drying. These can be easily detected by kneading up some of it with water to the proper consistency, shaping it into a rough brick or cube, and setting it to dry. Others will not show cracking for several hours. If the clay dries intact, then make another brick by hand and set it over a boiler or in an oven at a temperature of about 150 degrees F., and observe the results. A clay must be able to stand a certain amount of abuse in drying in order to give a large output of finished products.

PRACTICAL INSTRUCTIONS AS TO SAMPLING

Many people send a few ounces of clay to a testing laboratory and expect to be told all about its properties and uses. It is not possible, however, to make any definite statements unless at least two pounds of clay are submitted, and then the results of tests on a sample of this size should, in many cases, be only preliminary to testing a larger sized sample.

Since few clay or shale deposits are uniform in character throughout their entire thickness, the selection of samples for testing purposes is a matter of some importance.

If the deposit appears to be uniform, then the sample should represent an average of the depth of the face it is proposed to work. The average sample should be supplemented by two or three other samples taken from different depths, as appearances are frequently misleading in clay investigation. Many persons pick a small sample of clay from the surface of a deposit and send it to be tested. The results of tests from this kind of sampling are generally useless. The body of material, when opened

up for working, may give entirely different results from the thin veneer of weathered clay overlying it. In a locality where industries have been located for a long time, working satisfactorily on a material which occurs widespread, and uniform in character, the necessary information may be obtained merely by inspection of a suitable site in the vicinity of the older plants. This proceeding is often, but not always, safe where the manufacture of common brick only is concerned. Where any of the highest class of clay products are to be made, the cheapest method is to take every possible precaution at the outset of the enterprise.

LABORATORY TESTS

The visible impurities in a clay, which may produce defects in the process of manufacture or in the appearance of the finished ware, can be detected only by working up and burning test pieces made from the clay.

A good deal of time and money has been expended on the chemical analysis of clay, and many chemists have been rash enough to state in reports the kind of wares a clay will make, based upon the results of their chemical analysis alone. There may be special instances, as in the case of some high grade clays, where the chemical analysis is of value; but it is worthless for the general group of clays or shales in the manufacture of structural ware.

What the clay worker desires to know about a clay or shale is:—

1. Its plasticity and working qualities.
2. The rate of drying.
3. The exact drying and burning shrinkage.
4. The commercial limit of burning.
5. The porosity and absorption of the burned wares.
6. The actual difficulties encountered in burning, such as cracking, warping, or swelling, and scumming or whitewash.

Many of the important clay-working plants in the United States and England, especially those making a variety of wares, have an experimental laboratory, with small kilns for burning trials, in charge of a competent ceramist. These firms test a large number of clay samples which are sent to them from outside sources. Three or four of the State universities give courses in Ceramic Engineering and have fully equipped clay-testing laboratories. A certain amount of commercial work is done, for which fixed charges are made, according to the scope of the investigation. The tests are conducted by experienced men, whose reports are reliable, and extremely valuable to the person or company about to start a clay-working industry.

Most of the manufacturers of clay-working machinery have a clay-testing department on their premises. These people invite prospective customers for machinery to send samples of their clay and have it worked up into specimens of ware. They generally make the tests free of charge. The specimens of burned wares sent back by the machinery companies to their prospective customers are generally perfect in every respect. These samples should be regarded as a standard to be ultimately attained, however seldom reached, in the everyday world of clay-working.

TESTING UNDER WORKING CONDITIONS

If a company or individual wishes to establish an important clay-working industry at a certain place, to make a certain class of wares, a reasonable way to proceed in the test of their clay—provided the field examination was satisfactory—is as follows:—

Take an average sample of, say 50 pounds, from top to bottom of the workable depth of the deposit, if it is uniform in appearance, or as many samples as there are different beds. Have a complete set of laboratory tests made from the samples. If the laboratory tests prove satisfactory, then make arrangements with some firm,

outside the zone of competition, who are making wares similar to those required, to put a large quantity of clay through their process and to burn it in their kilns. It is important to have an experienced man do the sampling and accompany the clay to its destination, so that he may observe the behaviour of the material in the various stages of manufacture.

The proper location of the deposit and the assurance of the suitability of the clay for the purpose for which it is to be used are absolutely essential to begin with.

The plan of the buildings, the design of the kilns or driers, and the selection of the best types of clay-working machinery, should be done by a competent ceramic engineer.

It is impossible to provide against all the troubles which may arise in new localities when dealing with a new material; but the chances for the occurrence of trouble can be materially lessened by proper precaution.

The business of manufacturing clay products is a desirable one in many respects. It gives healthy employment and produces articles of great use to a community. It is a fairly profitable business when brains and technical skill, as well as capital, are invested in it, varying nowise in this respect from any other complex, producing business. It is just as easy, however, for the unwary novice to lose his money in a homely looking clay-working plant as it frequently is in the more spectacular operations of metal mining.

ROAD MATERIALS DIVISION

H. Gauthier

The activities of the Road Materials Division have been curtailed to a certain extent during the present year on account of the resignation of Dr. K. A. Clark as chief of the division. However, investigations on road materials were carried on in Ontario and in Nova Scotia by the two remaining engineers, R. H. Picher and the writer—who worked together.

The first part of the summer was spent between Gananoque and Napanee in Ontario, with headquarters at Kingston. During the balance of the field season investigations were started in Nova Scotia, along the Halifax-Windsor, Halifax-Truro-New Glasgow routes, and in the Annapolis valley.

Since 1914, investigational work on road materials has been undertaken in every province of the Dominion, except the Maritime Provinces. In Ontario and Quebec this work has taken the form of material surveys along some of the routes of proposed main provincial highways. All available supplies of materials were then examined, mapped, and such sampling done for subsequent laboratory study as was necessary to determine the quality of such material, and to enable discrimination to be made between good and poor deposits. In the western provinces, road material investigations have been more in the direction of trying to determine how use can be best made of such materials as exist, in order to get serviceable results in road building.

By means of these surveys the staff of the division was afforded an opportunity of becoming familiar with the local conditions and problems connected with road building in the various provinces. Considerable information on the relative road-making qualities of a wide variety of materials has been gathered, which will be valuable to the highway engineers and contractors of the country.

In compliance with a special request from the Highway Board of Nova Scotia, it was found advisable to extend the field of work to that province. Consequently, some time was spent there, with the object of finding out in just what way the Road Materials Division could function best in gathering information wanted by the Highway Department and engineers.

A final report on the available supply of road material along the Gananoque-Napanee section of the Ontario provincial highway is under preparation. The investigational work in Nova Scotia has not advanced sufficiently for formal report.

A brief summary of the work accomplished in Ontario and in Nova Scotia follows:—

ROAD MATERIAL SURVEY ALONG THE GANANOQUE-NAPANEE SECTION OF THE TORONTO-MONTREAL HIGHWAY, ONTARIO

The road material survey for the Toronto-Montreal highway was started in 1914, and continued during the summers of 1916, 1917, and 1919. Reports have been published[1], or written and will be published,[2] dealing with the various sections of this proposed provincial main highway. That stretch of the route from a point seven miles west of Gananoque to Napanee remained to be surveyed, and the aim of the field work undertaken during last summer was the completion of this survey.

The entire strip of land extending from the St. Lawrence river to from 4 to 7 miles inland was traversed. This includes the southwestern part of Pittsburgh town-

[1] Road Material Survey in 1914, by L. Reinecke, Memoir 85, Geol. Surv.
Report on Road Materials along the St. Lawrence river, from the Quebec boundary line to Cardinal, Ont., by R. H. Picher, Bulletin 32, Mines Branch.

[2] Reports dealing with the sections Cardinal-Gananoque and Napanee-Port Hope.

ship, and the southern part of Kingston township in Frontenac county, and nearly all of Ernestown township, and the eastern portion of North Fredericksburgh township in Lennox and Addington counties.

The work consisted in the examining, locating, and mapping of all deposits of bed-rock, and in sampling the more important sources of supply for laboratory examination.

Throughout this district the route followed by the proposed highway is the Front or river road from Gananoque westward to Kingston, and from there the York road through Cataraqui, Westbrook, Odessa, and Fellows to Napanee.

The alignment of the highway is pretty straight all the way, with no right-angled turn, and only a few steep grades at Barriefield, Cataraqui, and Westbrook. The distance from where this survey was started, to Napanee, is 30 miles. For nearly all of that distance occurrences of bed-rock close to the highway are common, and constitute a plentiful supply of road stone for its construction and maintenance.

The area surveyed is underlain by Palæozoic sediments of the Black river and Trenton formations, composed of limestone and shales. Igneous rocks of pre-Cambrian age also occasionally occur, but only through the eastern part of the examined area. These rocks, which are in intrusive contact with the Black River limestones, are in chronological order, beginning at the oldest: Grenville gneisses and quartzites, Laurentian gneisses, and Algoman granite.

The more important occurrences of granite are located at Barriefield and Kingston Mills. The gneisses are found in scattered outcrops along the St. Lawrence river, between Barriefield and Gananoque. Their occurrence becomes more and more common, eastward through the area surveyed in 1919.

The boss-like occurrence of granite at the Kingston Mills locks on the Rideau canal covers an area of over half a mile square, and rises to approximately 75 feet above its lowest point. On either side of a deep gorge cut by the Cataraqui river at the locks, and along the edges of the outcrops close to the roads, are excellent exposures, with plenty of good faces for quarrying.

The general character of the granite, which is largely composed of feldspar (orthoclase), is reddish to pink, medium to coarse grained, and fairly massive.

At Barriefield, the granite occurs in the form of a dike cutting through the gneiss.

The rock is bright red with bluish dots, medium to coarse grained. It was formerly quarried for monumental and building stone.

Throughout the entire area surveyed, outcrops of limestone are plentiful. Limestone of the Black River formation is especially well developed in the vicinity of Kingston. It has been quarried for many years there, and so largely used in the city buildings that Kingston is known as the "Limestone City."

This formation forms a prominent flat-topped hill at Barriefield, and the beds are exposed to a depth reaching 50 feet in places on the margin of bluffs on either side of the Cataraqui river, north of Kingston. In many instances the stone has been quarried for road materials, and openings with good exposures are found at short intervals between Kingston and Kingston Mills, and east of Barriefield along the Front and the Middle roads. West of Kingston, the more important occurrences of Black River limestone are north of Portsmouth, northwest of Cataraqui, and along the lake shore west of Collins Bay.

The character of the stone is of three main types. In ascending order they are: a greenish, sandy limestone, and shales, irregularly bedded, and uneven; a dove-blue to brownish-grey, dense, almost lithographic limestone, with, in places, numerous fine crystals of calcite scattered through its matrix; and a fossiliferous, dark grey, fine to coarse grained limestone. The greater part of the stone seen in the exposures is of the dense-textured type. It generally occurs in well defined and flat lying beds, and is, as a rule, fresh.

In the western half of the district surveyed, and especially to the east and northeast of Napanee, the occurring limestone resembles that of the Trenton formation

near Ottawa and Montreal. There is very little noticeable variation in the character of the limestone along the route of the proposed highway from Westbrook to Napanee. The general character of the stone is thin bedded, laminated, dark coloured, uneven and highly fosiliferous limestone, with thin, black, shaly partings. At Napanee the limestone is somewhat different. It includes irregular layers of dense stone like that near Kingston, interbanded with a coarse and more crystalline variety. Some of the stone presents cavities lined up with crystals of calcite.

A large number of outcrops lie within hauling distance of the highway. In that section the more important deposits are located at Westbrook, northeast of Odessa, at Morven, and near Napanee.

There are several quarries from which stone has been obtained from time to time for local road work. In most cases more stone may be had without trouble.

Forty samples, including granite, Black River, and Trenton limestones of the various types, were collected and tested. The tests ordinarily made in examining stone to be used as road material are the following: abrasion, toughness, hardness, cementing, specific gravity, and water absorption.[1] To make these tests, the sample must consist of sixty pieces of rock, of chunky shape, i.e., not flat or splintery, approximating in size and general shape to a 2-inch cube, and also a block of stone, free from fractures and checks, rectangular in shape and at least 4 inches by 4 inches by 6 inches in dimensions.

In the final report the road-making qualities, and the comparative value of the various classes of rock sampled and tested, will be discussed. In the discussion, conclusions will be based on the results of laboratory tests, and on service conditions as revealed by the inspection of roads on which they have been used. The report will also contain a detailed description of each deposit of bed-rock occurring in the area traversed, from which road stone could be obtained. The outcrop areas which were mapped and examined number over fifty.

ROAD MATERIALS IN NOVA SCOTIA

Since 1917, in the province of Nova Scotia, every mile of highway has been under the control of the Nova Scotia Highway Board.

This Board has a large highway programme, partly mapped, but is finding it difficult to secure proper surfacing material. In some parts of the province, they have no difficulty in this respect, but in many places there appears to be no suitable material, or at least they have been unable to find such.

Investigations have been carried on in the western provinces in connexion with sand and clay roads, in order to determine how best to use such road materials as exist in order to get satisfactory results. This same problem presents itself in certain parts of Nova Scotia where the country is devoid of rock or gravel.

The main object of the work started in Nova Scotia was to observe conditions and try to determine a plan of work which the Road Materials Division could carry out, and which would best aid the Provincial Highway Department to get a better understanding of the road building materials at their disposal, in their relation to the various road building conditions that have to be met.

Thanks are due to Mr. J. W. Roland, ex-chief engineer of the Provincial Road Board, for his co-operation in the matter of going over the situation, and in doing all in his power to aid in getting a programme of work planned along the most useful lines possible.

Nova Scotia, with 18,000 miles of highways, has an excessive mileage of roads, considering its area, population, and the revenues for their betterment.[2] The pro-

[1] Explanation of these tests and general limiting values for broken stone to be used in various types of road construction are given in the Mines Branch Summary Report for 1918, page 170.

[2] Report of the Provincial Highway Board of Nova Scotia, 1918, p. 5.

posed main highways aggregate some 2,000 miles in length. These main trunk roads, after improvement, would be an asset of undoubted value to the province, and would open up to tourist travel portions of Nova Scotia of great scenic beauty.

The object of the Road Materials Division, in the past, has been to confine itself as much as possible to work upon the main interprovincial highways. So far as Nova Scotia is concerned, the main interprovincial road is that connecting St. John —the commercial metropolis of New Brunswick—with Halifax, the capital of Nova Scotia. Beginning at the boundary between New Brunswick and Nova Scotia, the route followed is via Amherst and Truro, a distance of about 75 miles. From Truro to Halifax—a distance of 62 miles—the route will be through Stewiacke, Shubenacadie, Waverly, and Bedford, the total distance from the boundary line to Halifax being about 137 miles. The route Halifax-Digby via Windsor and the Annapolis valley also connects Halifax with St. John, N.B., and is one of the more important provincial routes. The distance from Halifax to Digby is 154 miles. There are good boat connexions between Digby and St. John, across the Bay of Fundy, which is 48 miles wide there. This route is one of the alternative routes from Halifax to Yarmouth. The latter city is 67 miles from Digby, the total distance from Halifax to Yarmouth being 221 miles. The south shore route, via Chester, Bridgewater, Liverpool, and Lockport, is 230 miles long, and part of it is through unsettled and wild country.

The improvement, even of existing main highways through the province, is still in its infancy. While only a small mileage of these has been surfaced with gravel, yet it is a fact that a big improvement has been made throughout every section of the province. On a great part of the routes above mentioned, culverts and bridges of a permanent nature have been built, and stretches of improved gravel roads or waterbound macadam have been built in the more thickly populated centres. The greater part of the work being done, however, is of a preliminary nature, and consists in grading, ditching, and preparing the subgrade for future surfacing.

Along certain sections of these routes there are plenty of occurrences of bedrock outcrops from which good road surfacing material is available; along other sections the country is thickly drift covered, but gravel deposits are encountered at intervals. There are areas, however, varying in extent, where no suitable material can be found, or where the only occurring road building material is either clay or sand.

The work started last summer by the Road Materials Division consisted, mainly, in the study of the local conditions, and in the gathering of the more pressing information needed by the highway engineers. Some of the proposed main roads were visited, and the soil conditions and character of the available road materials examined, in order that systematic work could be planned for the future. The routes along which the inspections were made are the Halifax-Truro-New Glasgow highway, the Halifax-Yarmouth highways, via Windsor, the Annapolis Valley and Digby, and via the south shore. Some time was also spent in extending an investigation, having as objective the locating of some suitable material within hauling distance of the highway, between Windsor and Hantsport, and over an area northwest of Kentville, where no suitable material has yet been found.

Many samples of rock, gravel and soil were collected, and sent to the laboratory at Ottawa for examination during the winter.

APPENDIX

PRELIMINARY REPORT on the investigation of the manufacture of peat fuel, conducted by the Joint Peat Committee of the Federal Government and the Government of Ontario, up to December 31, 1920; together with a statement of plans and outline of work to be done during the year 1921.

B. F. Haanel

Secretary to the Committee

It has been stated on many occasions that the investigation being conducted by the Peat Committee is concerned with the determination of the feasibility of manufacturing peat fuel on a commercial basis in Canada, under present day conditions; but since confusion appears to exist with regard to the activities of the Peat Committee, which has given rise to impatience on the part of the public regarding the results so far obtained, the committee deems it desirable to restate certain facts.

The possibility of utilizing the enormous sources of heat energy lying dormant in the peat bogs of Ontario was investigated some twelve years ago by the Mines Branch of the Department of Mines of the Federal Government, and at the conclusion of this investigation it was stated that peat fuel, under conditions existing then, could be manufactured commercially on a small scale to compete with coal, for certain purposes. The conditions referred to were cheap labour and plant cost, consequently it was possible to employ a type of machine which was being operated in large numbers in Sweden, Russia, and other European countries.

The conditions in Canada for manufacturing peat fuel were so similar to those existing in Sweden that the technical officers in charge did not consider that experimentation would be necessary. A small plant of thirty tons capacity, complete in every respect, was, therefore, imported from Sweden, and erected on the Alfred bog, which had previously been prepared for manufacturing operations. It was intended, moreover, that this installation should serve as a demonstration plant, to show those interested in the manufacture of peat fuel how to manufacture the peat content of a bog into a fuel, by the only economic process known to exist at that time. In other words, it was to serve the same purpose regarding the development of our peat bogs as experimental farms scattered throughout the Dominion of Canada serve the purposes of the farmer. The manufacture of peat fuel was demonstrated during two seasons, at the conclusion of which time it was decided to dispense with the plant and bog, and sell the same to private parties; inasmuch as the main objective of the Government's practical demonstration of economic peat manufacture had been accomplished.

In the final report of the work done at the Alfred bog under Government auspices, it was stated that, in order to manufacture peat fuel on a large commercial scale, it would be desirable to reduce manual labour to a minimum, and to introduce labour-saving devices wherever possible. As a result of this recommendation, private parties did attempt to introduce mechanical labour-saving devices in the shape of a new type of Anrep machine, which was installed on the bog, prior to the war. Experimentation with this machine, however, was cut short owing to the difficulty of obtaining financial assistance, after the declaration of hostilities; and no work was consequently done to develop the peat resources of Ontario and other parts of Canada until the Ontario and Dominion Governments decided to appoint a joint committee to investigate the feasibility of manufacturing peat fuel. This committee was appointed in 1918, and shortly after its appointment organized and made preparations to conduct an investigation.

It should be stated here, that the Ontario and Federal Governments, independently, decided almost simultaneously to investigate the possibility of utilizing the peat resources of Canada, for fuel purposes, a decision which was largely influenced

by the precarious fuel situation then existing. The Ontario Government decided to erect a peat plant of the Anrep type; while the Federal Government made plans to construct and erect, at Alfred, a peat machine of the Moore type. Since there was doubt in the minds of the Committee regarding the value of the two types of machine for the commercial manufacture of peat fuel, it was decided to thoroughly test the two types in order to ascertain which type of machine would be the best suited to Canadian bogs, or to determine the best features of each type.

The design of the Anrep machine was very considerably altered, and several innovations introduced in order to eliminate the large amount of time lost in altering the position of the main part of the machine, namely, the excavator element, on the field, and to otherwise increase its efficiency. The principal improvement was the mounting of the machine on caterpillar aprons. This obviated the necessity of moving the machine on specially laid tracks, and also permitted a greater degree of flexibility. The main parts of both machines were, so far as possible, made identical, so that if one type was found to be inferior to the other, it could be altered, at little expense, to conform to the best type. The mounting of the machines on caterpillar aprons was a new departure in the construction of peat machines; necessitating not only an original and entirely new design in the caterpillars themselves, but also alterations in the design of other parts of the machine. Consequently, a large amount of experimentation and alteration had to be done before the caterpillar elements could be pronounced satisfactory. The design of other parts of the two machines was also materially improved; notably the excavating buckets, and a considerable amount of work was required to make those satisfactory in every respect. The major portion of the required alterations were made during the season of 1919, and both machines were given a thorough mechanical test during that season. An attempt was made to give both plants a commercial demonstration during the season of 1920, but it was found impossible to operate them to full capacity and to take advantage of the full working season.

The Anrep system it may be pointed out, consists of two main elements, (1) the excavating element, which operates as a unit by itself; and (2) the distribution and spreading system or element. The spreading system employed with the Anrep peat machine, and which is always considered an inseparable and most important part of the Anrep method of manufacturing peat fuel, consists of a rectangular track layout, with rounded corners around which cars, operated by a cable way, actuated from the power plant situated on the excavator element, which delivers the pulped peat to a spreader, and which is operated at right angles to the line of travel of the excavating element. With this system, nine men are required to load cars and spread the peat on the field, and in addition to these very high labour costs, a serious loss of time is also occasioned in moving the tracks, an operation which must be performed at stated intervals—depending on the forward motion of the excavating element. The capacity was also reduced owing to the difficulty encountered in delivering a continuous supply of cars to the spreader.

The principal innovations in the Moore system are, (1) the unique device employed for delivering the pulped peat to the spreader and laying it on the field; and (2) the method of excavating the raw peat. The former is accomplished by delivering the pulped peat from the macerator continuously onto a belt conveyor which is supported on a bridge work some 160 feet long, which is attached to the main peat machine at right angles to its direction of travel. The delivery and spreading of peat is, therefore, continuous and automatic, but unlike the Anrep system, the peat is spread parallel to the direction of travel. With the Anrep system the peat is spread at right angles to the direction of travel of the excavating element. As a result, the Moore system requires a much greater length of working face than the Anrep system, in order to lay its full season's production on the field, but the number of men required to operate it to full capacity is very much less than the full complement of men required to operate the Anrep system.

OPERATION OF PLANTS DURING THE SEASON 1920

Both plants were operated during the entire season, although not continuously, the Anrep plant being operated on that portion of the field which had been prepared several years, and which, consequently, was in the best of condition for manufacturing peat fuel to advantage. The Moore plant, on the other hand, was operated on that portion of the bog lying adjacent to the C.P.R. tracks which had not been drained, and was, therefore, inferior to the other portion of the field. This handicapped the Moore machine very seriously; but it was the desire of the Peat Committee to give the Anrep unit every possible advantage in order to prove its value, since it was of standard design as regards the principles employed in excavating and spreading, and it was contemplated that the Moore machine would require a great many alterations before it could be put in working order. Notwithstanding the great handicaps under which the Moore plant operated, it became manifest early in the operations that this plant would not have to be seriously altered in order to put it into good working shape.

Fuel manufactured.—Between 5,000 and 6,000 tons of standard peat fuel were produced during the season of 1920, the major portion of which was sold to householders in Ottawa, Peterborough, and other towns, and a certain portion sold for commercial purposes.

RESULTS OF INVESTIGATION UP TO DATE

Although it is not possible for the Peat Committee to state that peat fuel can or cannot be manufactured on an economical commercial basis, as a result of the investigation so far conducted, the Peat Committee can definitely state:—

1. That the Anrep plant, as it stands, is in no sense commercial.
2. That the Moore plant under certain conditions can be employed commercially for the manufacture of peat fuel.
3. That the Anrep excavating element is the superior of the two, and the logical one to employ; while
4. The Moore spreading system is far more efficient, and is the logical spreading system to employ.

The main difficulty with the Anrep machine is the high cost of labour involved in the spreading system, and the large amount of time lost in changing tracks and in delivering a continuous supply of peat to the field, resulting in reduced capacity. The main difficulty with the Moore system is the excessively long working face which is required, an inherent difficulty which prevents this type of machine from being employed intensively on a bog of average dimensions.

In order to manufacture peat fuel on a large commercial scale during the comparatively short working season it is absolutely essential that the bog be worked intensively, that is to say, the largest number of units must be employed. This can only be accomplished by employing an excavator of the Anrep type combined with a spreading system of the Moore type, and, moreover, it is essential that all the manufacturing units be driven by electric motors supplied with current generated in a central station, which will effect a further reduction in costs.

RECOMMENDATIONS OF THE PEAT COMMITTEE

On the strength of the concrete results which the Peat Committee now have on hand, and after very careful consideration of these results, they recommend that the Anrep excavating element, which requires no alteration, and which is in as perfect condition as it is possible to put it, be combined with the Moore spreading system. This spreading system, in order to meet the requirements of the Anrep machine, will have to be specially designed, inasmuch as the bridge work necessary to support the

belt conveyer, will be some 850 feet long, it will move at right angles to the direction of travel of the excavator, and lay peat in 800 feet rows. The designs for this new spreading system have already been thoroughly worked out, and are sufficiently complete to be placed in the workshop for fabrication. With this new element, the Anrep excavator can be operated at full capacity throughout the working hours, and deliver pulped peat continuously to the field spreader, which will lay down peat in a direction parallel to the belt conveyer. While no attempt will be made to describe this transportation system, in detail, it is necessary to point out that the design of the new system required a large amount of work and expert advice, and in order to reduce chances of failure to as great a degree as possible, the Peat Committee enlisted the expert opinion of engineers and companies who had experience in belt conveying systems used for various purposes.

It is also the intention of the Peat Committee to operate the Moore plant as it stands, continuously throughout the season of 1921, on a strictly business basis, with the minimum complement of men, and without the attention of the expert engineering staff. This plant, thus operated, will serve as a demonstration to those interested in the manufacture of peat fuel, and will also enable exact figures as to cost of manufacturing, harvesting, etc., to be obtained.

It is imperative that the combined plant above mentioned be erected, mechanically tried out, and commercially demonstrated, before the Peat Committee can offer a definite opinion regarding the general feasibility of manufacturing peat fuel on a commercial scale in Canada; but it must be understood that even though the equipment is placed on the field early next season, it will be absolutely impossible to more than operate it to determine weaknesses and changes which may have to be made in the design, and to give it a thorough mechanical test, at the same time, of course, manufacturing a small quantity of peat fuel. The *commercial* demonstration of the combined plant cannot possibly be made until the following season, and its commercial feasibility may not be determined even at its conclusion; but the Peat Committee have every reason to believe that the demonstration which will have to be conducted during the season of 1922, in order to demonstrate the commercial feasibility of the new plant, will afford sufficient data to enable the Peat Committee to decide definitely whether or not peat fuel can be manufactured on a commercial basis, at a profit, under the average conditions existing in Canada at the present time.

In addition to the above programme of work, the Peat Committee has constructed a small peat machine which can be operated to advantage with two men and a boy, or say three men, by farmers or groups of farmers, for the purpose of supplying a cheap and satisfactory fuel for their own immediate use, or for the use of the inhabitants of villages and small towns. This machine is already constructed, and is partially erected, and its utility for the purpose for which it was designed can be determined without difficulty in a very short time. This part of the work will proceed along with the other.

The problem, therefore, with which the Peat Committee is confronted, and which it is hoped will be solved at the conclusion of the season of 1922, resolves itself, principally, into the design of a machine which will be capable of manufacturing a large quantity of peat during a comparatively short working season, with the minimum employment of manual labour, and at a cost which will permit the fuel so manufactured to compete with coal at ruling prices. The present day conditions which the Peat Committee have to meet are: (1) greatly increased labour costs—twice, and in certain cases three times what they were prior to the war—and (2) greatly increased cost of materials and machinery for general plant employed. These costs have mounted to two and three times what obtained prior to the war. These conditions, coupled with our unstable labour market, and great difficulty in getting plant fabricated and delivered at the required time, are mainly responsible for the time absorbed in the investigation, and have severely handicapped the Peat Committee's efforts.

OTHER METHODS TRIED IN THE MANUFACTURE OF PEAT FUEL

Since there are to-day, a great many people who still believe that it is possible to manufacture peat fuel continuously, by employing processes different from the one which the Peat Committee is demonstrating, it may be of interest to briefly state efforts which have been made to lengthen the manufacturing season and make the manufacture of peat fuel more or less continuous. It has been appreciated by all investigators, who have devoted their attention to the manufacture of peat fuel, that the development of the peat resources of the world would be greatly enhanced if peat operations could be conducted throughout the twelve months of the year instead of being limited to the summer season, and with this object in view, the possibility of separating the large quantity of water from the raw peat by pressure or by artificial drying, and then briquetting the residue obtained, *was thoroughly investigated.* These investigations have been conducted by the ablest men in European countries, and a very large amount of money has been expended and lost in the various attempts which have been made to adapt such processes to the manufacture of peat fuel. Despite the fact that the ablest investigators in peat devoted their entire attention to this problem, all such attempts have utterly failed. To-day, therefore, the only economic process which exists for the manufacture of peat fuel is that which depends upon the forces of nature for the removal of the large quantity of water contained in the raw peat, hence this is the only process which is being operated commercially in the peat-using countries of the world. This progress is, moreover, the result of all the efforts which have been made by investigators, for a period covering more than a century, to utilize peat for fuel purposes.

The Peat Committee is not attempting to alter this process itself, but is endeavouring to conduct the various operations required in the process in a more economical manner than appears to be necessary at the present time in Europe. When the labour costs in European countries becomes as serious a factor as it is on the American continent—if it is not already as serious—then the peat-using countries of Europe will have to turn to Canada for information, instruction, and assistance concerning the manufacture of peat fuel. A very large amount of money, approximating several million dollars, has also been expended and wasted on various attempts made for manufacturing peat fuel in Canada, which involved the pressing of water from peat or its separation by artificial heat, and it is needless to state that all such attempts have absolutely failed because they were based on wrong principles. The British Isles have also suffered the loss of large amounts of money through similar futile attempts; for example, the amount of money which has been expended in exploiting the Ekenberg wet carbonizing process for the manufacture of peat fuel has amounted to over two million pounds sterling, and the Peat Committee has been recently notified that this process, developed at such an enormous cost, is also at the present day a failure.

While the Peat Committee place themselves on record as stating that the air-dried peat machine process is the only economic one known to-day, it desires it to be understood that improvements in the process of converting peat into a fuel for both domestic and industrial purposes may be greatly improved some time in the future. It is even within the realm of possibility that at some distant date peat fuel may be manufactured continually, or at least the length of the manufacturing season extended; but such improvements have not yet come to light; and if our peat resources are to be turned to the use of man at the present time, the only process which can be employed is that which makes use of the forces of nature for the removal of the water content. It is significant, that although the peat-using countries of Europe, namely, Ireland, Scotland, Norway, Sweden, Denmark, Holland, Germany, Russia, Italy, and other portions of the European continent, have been manufacturing peat fuel from their peat bogs for more than a century, Dr. Purcell,

peat investigator for the British Fuel Research Board, made the following statement last year:—

> "That the Fuel Research Board were convinced of the value of the work being carried out here is, I think, evident from the fact that they have sent me to Canada specially to report on the work carried out at Alfred. I have now spent some time at Alfred and I think it is only right that I should say that in my opinion the work carried out there is in advance of any work which to my knowledge has been done elsewhere."

Dr. Purcell is an independent investigator, and is thoroughly acquainted with the work which is being done along this line on the European continent. His opinion, therefore, carries great weight.

THE MANUFACTURE OF PEAT IN FOREIGN COUNTRIES

It may be of value here to state that the peat-using countries of Europe are, like Canada, handicapped by a short manufacturing season, yet, in spite of the short season, a very large portion of the fuel requirements of certain of the European countries is supplied by peat fuel; for example, 60 per cent of the fuel requirements of Ireland are supplied by the manufacture of hand-cut, air-dried peat fuel, while in Denmark alone the annual production of peat fuel is estimated at over a million tons. Sweden similarly produces large quantities of peat fuel; in fact, uses peat powder as a fuel on one of her state railways. Before the war, Russia manufactured very large quantities of peat fuel, according to some authorities as high as six million tons; and other European countries, notably Holland, Germany, and Italy, use peat fuel in industrial plants as well as for domestic purposes. It is, therefore, reasonable to assume that under similar conditions, Canada could manufacture sufficient peat fuel to very largely decrease the quantity of coal which it is now necessary to import annually.

COST OF MANUFACTURING PEAT FUEL

Inasmuch as the Peat Committee's investigation is not in any sense complete, and that certain essential data have not yet been determined, it is not advisable to state an estimated cost of manufacturing a ton of peat fuel based largely on assumptions. The cost of manufacturing peat fuel can, therefore, only be definitely stated at the conclusion of the investigation.

(Signed) **B. F. HAANEL,**
Secretary, Peat Committee.

OTTAWA, Ont., January 26, 1921.

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